Central Yukon
Rapid Ecoregional Assessment

Memorandum II. Datasets, Analytical Models and Tools

Prepared for:

Department of the Interior
Bureau of Land Management
Rapid Ecoregional Assessments

Submission Date:
16 February 2015

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Acronyms Used In This Document

ADF&G	Alaska Department of Fish & Game
ADNR	Alaska Department of Natural Resources
AFI	Alaska Freshwater Fish Inventory
AKGAP	Alaska Gap Analysis Program
AKNHP	Alaska Natural Heritage Program
ALFRESCO	Alaska Frame-based EcoSystem Code
AMT	Assessment Management Team
AWC	Anadromous Waters Catalog
BLM	Bureau of Land Management
CA	Change Agent
CE	Conservation Element
CYR	Central Yukon REA
DEM	Digital Elevation Model
GCM	Global Circulation Model
GIPL	Geophysical Institute Permafrost Lab
HUC	Hydrologic Unit Code
ISER	Institute of Social and Economic Research
LCM	Landscape Condition Model
MAGT	Mean Annual Ground Temperature
MQ	Management Question
NHD	National Hydrography Dataset
NLCD	National Land Cover Database
REA	Rapid Ecoregional Assessment
SNAP	Scenarios Network for Alaska and Arctic Planning
Tech Team	Technical Team
TEK	Traditional Ecological Knowledge
UAF	University of Alaska Fairbanks
USFWS	United States Fish and Wildlife Service
USDA	United States Department of Agriculture
USGS	United States Geological Survey

Introduction

This memorandum summarizes data availability and methods for the proposed Change Agents (CAs), Conservation Elements (CEs), and Management Questions (MQs) as Task 2 and 3, Phase 1 for the Central Yukon (CYR) Rapid Ecological Assessment (REA). The proposed datasets for the analyses of CAs, CEs, and MQs are listed in this memorandum in a series of tables and are compiled in Appendix A. The datasets presented here are working lists: some proposed datasets may be removed while datasets identified later during the course of the project may be added. This memorandum is the first version provided to the Assessment Management Team (AMT) and Technical Team and will be followed by a presentation on January 29, 2015.

Objectives

Tasks 2 and 3 are nested within Phase 1: Pre-Assessment of the REA process, with the ultimate goal of establishing a Work Plan for Phase 2: Assessment. The objectives of Task 2 are:

1. Identify potential data to be used for the assessment.
2. Evaluate the data for utility (content, scale, completeness).
3. Evaluate the data quality (precision, consistency, documentation).
4. Make recommendations about data to be applied.
5. Identify data gaps (including limitations in accuracy and consistency within ecoregions) and evaluate if alternative MQs, CEs, and CAs should be proposed.

The objectives of Task 3 are:

1. List the CEs to be addressed, describing the approaches and categories in which they will be treated.
2. Describe specific assessment methods to address MQs.
3. Build prototype Conceptual Models for CEs with a suite of key ecological attributes identified.
4. Identify, describe, and recommend models, methods, and tools for characterizing CEs, CAs, and their interactions.
5. Evaluate methods and tools for their ability to perform as intended.

Since much of the data that will be required for analysis is largely dependent on the methods selected, we present methods and data simultaneously in this document. The goal of data discovery was to obtain source datasets that would then allow us to move forward with additional processing steps.

In addition to identifying data an evaluation of the data for 11 quality criteria needs to be performed. Ideally, each data layer should be opened, inspected, and evaluated according to these 11 criteria. However, due to the amount of time it takes to evaluate the 11 quality criteria, and because additional datasets are continuing to be brought to our attention, we elected to defer data evaluation until we identify a final set of data layers. As such, this memo represents a status report on the state of data discovery to-date, with the caveat that full data quality evaluations will be conducted for all final source datasets.

Proposed datasets for CEs, CAs, and MQs

A summary of all CEs and CAs selected for analysis in the Central Yukon REA and the number of MQs by disciplinary topic are provided in Table 1 and Table 2. Additional details on CEs and CAs are provided within their corresponding sections.

Many datasets identified in this memorandum will be required for multiple analyses. To avoid redundancy, datasets are grouped by CEs and CAs into the following categories:

a. Climate Change
b. Permafrost
c. Fire
d. Invasive Species
e. Insects and Disease
f. Anthropogenic Uses
g. Terrestrial Coarse-Filter CEs
h. Aquatic Coarse-Filter CEs
i. Terrestrial Fine-Filter CEs
j. Aquatic Fine-Filter CEs

The dataset tables provided in this memo catalog all datasets identified to date to inform the analyses of CEs, CAs, and MQs. Spatial datasets were identified where available and relevant. However, in some cases, spatial data is either unavailable or not applicable. In such cases, either tabular data were identified or a review of available literature will be conducted. Data gaps are explained under individual CE or CA sections. Most of the MQs require datasets that are also required for the core analyses of CEs and CAs, therefore these data are not presented in the MQ discussion. However, since MQs are inherently additional products separate from the core analysis, additional data is sometimes required to fully address MQs. Such additional data are presented within the appropriate MQ sections.

Process Models

While conceptual models help inform the ecological relationships between ecosystem components, drivers, and processes, process models illustrate computational relationships or logical decisions within the context of a spatial or mathematical model to produce an output. Process models diagram data sources, geoprocessing procedures, and workflows, providing analytical transparency and allowing for repeatability of processes in the future (Bryce et al. 2012). Process models have been developed to represent the analysis of each CA and MQ, and they helped provide guidance for data discovery.

Conventions for Process Models

Process models are diagrammed according to the conventions in Figure 1 below (Bryce et al. 2012). Each process model will contain the following:

1. *A diagram* illustrating data and methods. These are key elements (datasets representing key attributes of CEs, CAs, and MQs) and procedures in the computational process, the relationship among them, and the flow of information and analyses.

2. *Descriptive text* explaining the diagram. Methods for developing process models for all MQs are similar: source datasets are computationally or spatially related to produce outputs that are further related to produce final products.

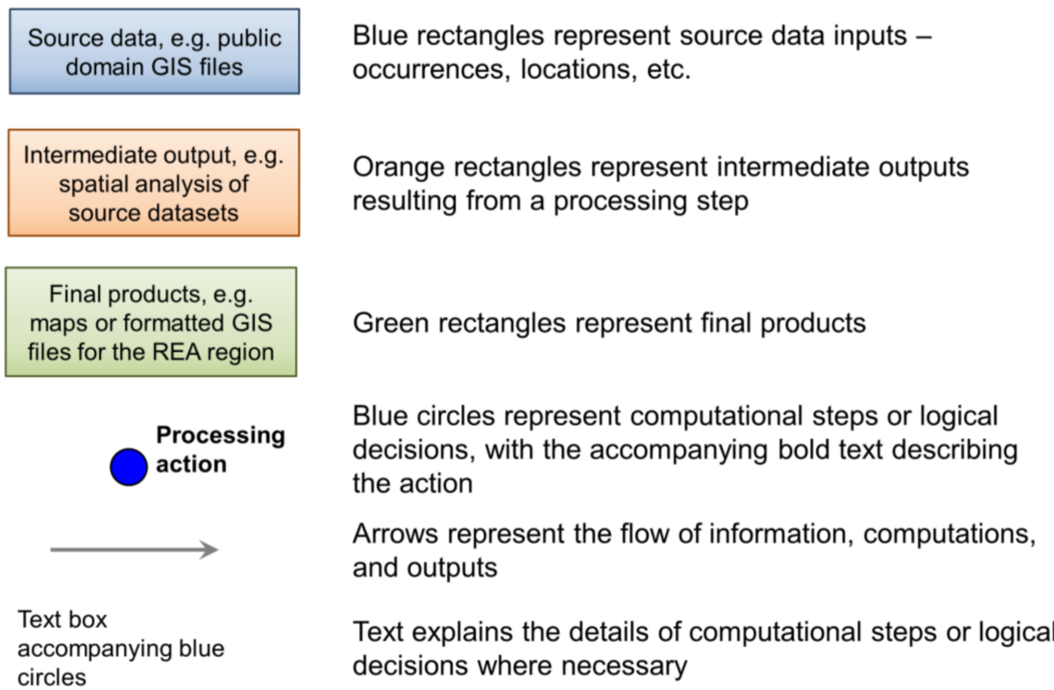

Figure 1. Conventions for Process Models.

Table 1. Proposed CEs and CAs.

Coarse-Filter Conservation Elements	
Terrestrial	**Aquatic**
Alpine Dwarf Shrub Tundra	Rivers and Large Streams
Alpine and Arctic Tussock Tundra	Small Streams (including Headwater streams)
Upland Mesic Spruce-Hardwood Forest	Large Connected Freshwater Lakes
Upland Mesic Spruce Forest	Small Connected Freshwater Lakes
Upland Low Shrub Tundra	
Lowland Woody Wetland	
Floodplain Forest and Shrub	

<table>
<tr><th colspan="2">Fine-Filter Conservation Elements</th></tr>
<tr><th>Terrestrial</th><th>Aquatic</th></tr>
<tr><td>Caribou (Rangifer tarandus)</td><td>Chinook salmon (Oncorhynchus tshawytscha)</td></tr>
<tr><td>Sheep (Ovis dalli)</td><td>Chum salmon (Oncorhynchus keta)</td></tr>
<tr><td>Beaver (Castor canadensis)</td><td>Northern pike (Esox lucius)</td></tr>
<tr><td>Snowshoe hare (Lepus americanus)</td><td>Sheefish / inconnu (Stenodus leucichthys)</td></tr>
<tr><td>Golden eagle (Aquilia chrysaetos)</td><td>Humpback whitefish (Coregonus pidschian)</td></tr>
<tr><td>Gray-cheeked thrush (Catharus minimus)</td><td>Dolly Varden (Salvelinus malma)</td></tr>
<tr><td>Trumpeter swan (Cygnus buccinator)</td><td></td></tr>
<tr><th colspan="2">Change Agents</th></tr>
<tr><th>Category</th><th>Subcategory</th></tr>
<tr><td rowspan="3">Abiotic Factors - Climate</td><td>Precipitation</td></tr>
<tr><td>Temperature</td></tr>
<tr><td>Thaw Date</td></tr>
<tr><td rowspan="2">Abiotic Factors - Fire</td><td>Return Interval</td></tr>
<tr><td>Vegetation Response</td></tr>
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<tr><td colspan="2">Invasive Species</td></tr>
<tr><td colspan="2">Insects and Disease</td></tr>
<tr><td rowspan="5">Anthropogenic Factors</td><td>Subsistence</td></tr>
<tr><td>Natural Resource Extraction</td></tr>
<tr><td>Transportation and Communication Infrastructure</td></tr>
<tr><td>Recreation</td></tr>
<tr><td>Energy Development</td></tr>
</table>

Management Questions

MQs reflect critical resource and management concerns in the region and focus the REA on those concerns. The Assessment Management Team (AMT) for the Central Yukon REA prioritized a list of 20 MQs (Table 2) through an iterative scoring process. Throughout this memorandum, MQs will be referenced by alpha-numeric codes (e.g., F3).

Table 2. High priority MQs selected by the AMT.

Abiotic Factors	
A1	How is climate change likely to alter the fire regime in the dominant vegetation classes and riparian zones?
B1	How is climate change likely to alter permafrost distribution, active layer depth, precipitation regime, and evapotranspiration in this region?
B2	What are the expected associated changes to dominant vegetation communities and CE habitat in relation to altered permafrost distribution, active layer depth, precipitation regime, and evapotranspiration?
C1	How will changes in precipitation, evapotranspiration, and active layer depth alter surface water availability and therefore ecosystem function (dominant vegetation classes)?
E1	How is climate change affecting the timing of snow melt and snow onset, spring breakup and green-up, and growing season length?
F3	How are major vegetation successional pathways likely to change in response to climate change, with special emphasis on increased shrub cover and treeline changes?
Anthropogenic Factors	
Q1	Which subsistence species (aquatic and terrestrial) are being harvested by whom and where is harvest taking place?
U1	Compare the footprint of all types of landscape and landscape disturbances (anthropogenic and natural changed) over the last 20 and 50 years.
U3	How and where is the anthropogenic footprint most likely to expand 20 and 50 years into the future?
Terrestrial Coarse-Filter Conservation Elements	
AH1	What rare, but important habitat types that are too fine to map at the REA scale and are associated with coarse- (or fine-) filter CEs that could help identify areas where more detailed mapping or surveys are warranted before making land use allocations (such as steppe bluff association with dry aspect forest)?
G1	Where are refugia for unique vegetation communities (e.g. hotsprings, bluffs, sand dunes) and what are the wildlife species associated with them?
G2	Which unique vegetation communities (and specifically, which rare plant species) are most vulnerable to significant alteration due to climate change?

Terrestrial Fine-Filter Conservation Elements	
AE1	Where is primary waterfowl (black scoter or trumpeter swan) habitat located?
L1	What are caribou seasonal distribution and movement patterns?
N3	How might sheep distribution shift in relation to climate change?
T1	The introduction of free-ranging reindeer herds to this region has been proposed. What areas would be most likely to biologically support a reindeer herd?
X1	What have the past cumulative impacts of road construction and mineral extraction been on terrestrial CE habitat and population dynamics?
X2	How might future road construction and mineral extraction infrastructure (e.g. both temporary and permanent roads [Umiat, Ambler, Stevens Village], pads, pipeline, both permanent and temporary) affect species habitat, distribution, movements and population dynamics (especially caribou, moose, sheep)?
Aquatic Conservation Elements	
W2	How might future road construction and mineral extraction infrastructure (e.g. both temporary and permanent roads, pads, pipeline) affect fish habitat, fish distribution, and fish movements (especially chinook, chum, sheefish)?
V1	How does human activity (e.g. mineral extraction, gravel extraction) alter stream ecology and watershed health (i.e. water quantity, water quality, outflow/stream connectivity, fish habitat, and riparian habitat)?

References

Bryce, S., J. Strittholt, B. Ward, and D. Bachelet.(2012). Colorado Plateau Rapid Ecoregional Assessment Final Report. Prepared for National Operations Center, Bureau of Land Management, U.S. Department of the Interior. Submitted by Dynamac Corporation and Conservation Biology Institute. Denver, CO. 183 pp

Chapter 1: Change Agents

Change agents (CAs) are those features or phenomena that have the potential to affect the size, condition, and landscape context of Conservation Elements (CEs). CAs include broad factors that have region-wide impacts: climate change, wildfire, permafrost, and insect and disease infestations. CAs also include factors that have localized impacts: invasive species and anthropogenic development, including infrastructure and resource extraction. CAs can impact CEs at the point of occurrence as well as through offsite effects. CAs are also expected to act synergistically with other CAs to have increased or secondary effects. Even though they are listed separately, not all development CAs occur alone. For instance, energy development requires other CAs, namely transportation and/or transmission infrastructure.

Climate Change

Climate change drives multiple types of change in the REA and is also part of feedback loops with other CAs (such as fire) and CEs (such as all Terrestrial Coarse-Filter CEs). Climate change will be assessed using 771 meter resolution climate variable data developed by the Scenarios Network for Alaska & Arctic Planning (SNAP) from downscaled General Circulation Models (GCMs). Subsets of the available climate data have been selected based on the needs of the project.

Datasets

SNAP projections focus on the five available GCMs that perform best in the far north (Walsh et al. 2008). GCMs are developed by various research organizations around the world. At various times, the United Nations Intergovernmental Panel on Climate Change (IPCC) calls upon these organizations to submit their latest modeling results in order to summarize and determine the current scientific consensus on global climate change. There have been 5 assessment reports from the IPCC dated 1990, 1995, 2001, 2007, and 2015. In support of the more recent reports, the Coupled Model Intercomparison Project (CMIP) was initiated. Currently SNAP has utilized the CMIP3 model outputs from the IPCC's Fourth Assessment Report (AR4).

SNAP obtains GCM outputs from the Lawrence Livermore National Laboratory Program for Climate Model Diagnosis and Intercomparison (PCMDI) data portal. PCMDI supports the Coupled Model Intercomparison Project (CMIP) and is dedicated to improving the methods and tools for the diagnosis and intercomparison of GCMs. SNAP uses the first ensemble model run and the historical 20c3m scenario as well as the projected B1, A1B, and A2 datasets for downscaling.

SNAP climate datasets have been downscaled to 771 meter resolution using PRISM (Parameter-elevation Regressions on Independent Slopes Model) methodology (PRISM 2008), which takes into account slope, elevation, aspect, and distance to coastlines. This downscaling uses a historical baseline period of 1971–2000; therefore, the 1971-2000 timeframe will be considered the historic baseline period for the Central Yukon REA. SNAP's downscaling methods are explained in detail at www.snap.uaf.edu.

A composite (average) of the five best-performing GCMs selected and downscaled by SNAP will be used in order to minimize uncertainty due to model bias. This project will focus on the A2 scenario, representing a realistic view of future emissions. Although the IPCC's most recent report, the fifth Assessment Report (AR5), refers to four Representative Concentration Pathways (RCPs) rather than the scenarios described in the Special Report on Emissions Scenarios (SRES) published in 2000, the slightly older model outputs used in this analysis are still relevant within the new framework. The A2 scenario outputs fall between those of RCP 6 (a mid-range pathway in which emissions peak around 2080, then decline) and RCP 8.5, the most extreme pathway, in which emissions continue to rise throughout the 21st century (Rogelj et al. 2012). Data for all variables are presented as decadal averages rather than as single year outputs in order to reduce error due to the stochastic nature of the GCMs, which mimic observed inter-annual variability of climate. Thus, the project will use climate data for the 2020s to represent the near-term future and the 2060s to represent the long-term future (Table 3).

Table 3. Summary of datasets for the climate change CA.

Dataset Name	Data Source	Status
Five Model Decadal Standard Deviation in Temperature (A2, 2 km grid)	Scenario Network for Alaska and Arctic Planning	Processed
Five Model Decadal Standard Deviation Precipitation (A2, 2 km grid)	Scenario Network for Alaska and Arctic Planning	Processed
Historical Decadal Averages of Annual Total Precipitation 1910-1999 (771 m grid)	Scenario Network for Alaska and Arctic Planning	Processed
Historical Decadal Averages of Seasonal Total Precipitation 1910-1999 (771 m grid)	Scenario Network for Alaska and Arctic Planning	Processed
Historical Decadal Averages of Monthly Mean Temperatures (771 m grid)	Scenario Network for Alaska and Arctic Planning	Processed
Historical Decadal Averages of Annual Mean Temperatures (771 m grid)	Scenario Network for Alaska and Arctic Planning	Processed
Historical Decadal Averages of Seasonal Mean Temperatures (771 m grid)	Scenario Network for Alaska and Arctic Planning	Processed
Projected Decadal Averages of Monthly Mean Temperatures (A2, 771 m grid)	Scenario Network for Alaska and Arctic Planning	Processed
Projected Decadal Averages of Annual Mean Temperatures (A2, 771 m grid)	Scenario Network for Alaska and Arctic Planning	Processed
Projected Decadal Averages of Seasonal Mean Temperatures (A2, 771 m grid)	Scenario Network for Alaska and Arctic Planning	Processed
Projected Decadal Averages of Annual Total Precipitation (A2, 771 m grid)	Scenario Network for Alaska and Arctic Planning	Processed
Projected Decadal Averages of Seasonal Total Precipitation (A2, 771 m grid)	Scenario Network for Alaska and Arctic Planning	Processed

Dataset Name	Data Source	Status
Projected Day of Freeze (A2, 771 m grid)	Scenario Network for Alaska and Arctic Planning	Processed
Projected Day of Thaw (A2, 771 m grid)	Scenario Network for Alaska and Arctic Planning	Processed
Projected Length of Growing Season (A2, 771 m grid)	Scenario Network for Alaska and Arctic Planning	Processed
Alaska Projected Decadal Averages of Monthly Snow-day Fraction (A2, 771 m grid)	Scenario Network for Alaska and Arctic Planning	Processed
Projected Alaska Climate-Biome Shift (A2, 2 km grid)	Scenario Network for Alaska and Arctic Planning	Processed

Model Methods

The primary SNAP climate outputs, those from which data for other climate variables have been derived, are decadal averages of mean monthly temperature and decadal averages of total monthly precipitation. Based on interpolation of running means, SNAP has created datasets estimating the date at which temperatures cross the freezing point in the spring and fall (termed "thaw date" and "freeze date" – although a direct correlation with ice on water bodies or in soils would not be expected). In addition, SNAP has used temperature data to create spatial estimates of potential evapotranspiration (PET) and monthly estimated snow day fraction, which is the percentage of precipitation expected to fall as snow (Figure 2).

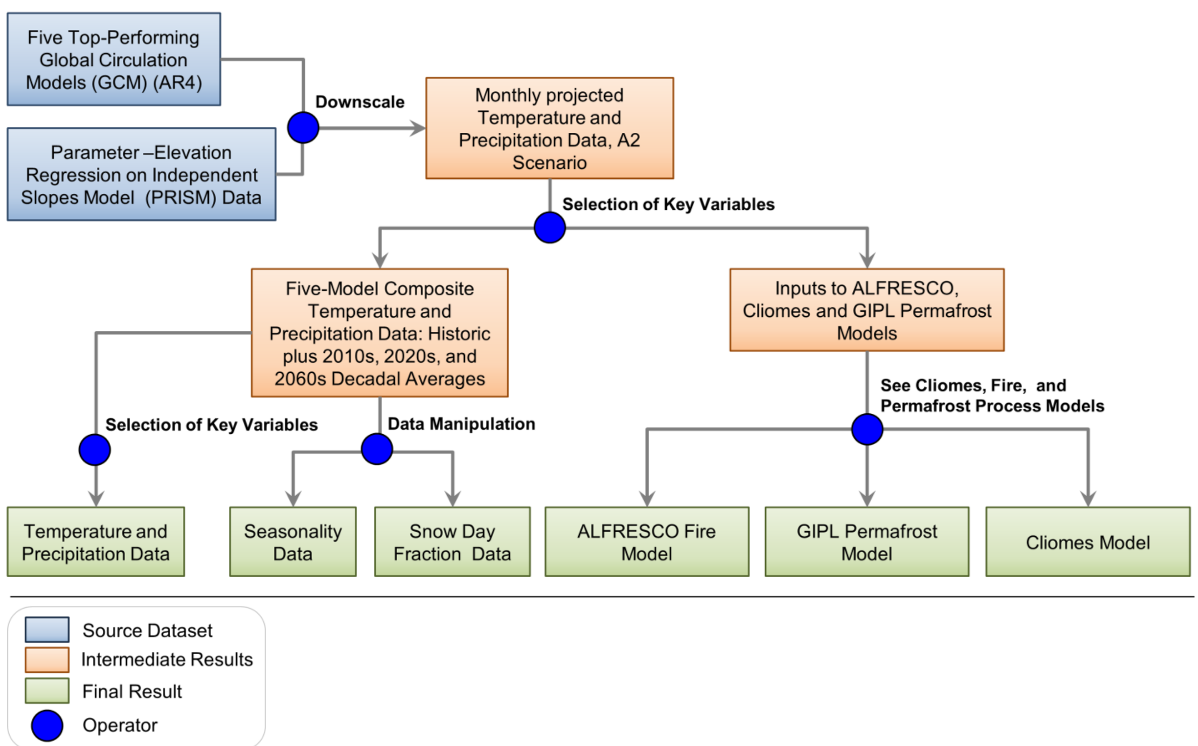

Figure 2. Process model for analysis of climate change CA.

SNAP has also used climate cluster analysis to create a “cliomes” model that grouped pixels based on similarity in 12 months of mean monthly temperature data and 12 months of total monthly precipitation data simultaneously. The resulting clusters can be used as a proxy for more holistic change in a regional context (Figure 3).

For the purposes of addressing MQs and effectively examining the relationships between climate and selected CEs, SNAP will provide both primary and derived climate data as described above. Ultimately, these datasets will be used in general discussion and analysis of climate change. A subset of these data will also be selected to analyze the potential impacts of climate change on CEs, based on specific climate-related thresholds determined from the literature. These datasets will be analyzed within the spatial distributions of CEs to summarize CE-related trends in a spatial or tabular format and to form the basis for qualitative discussion.

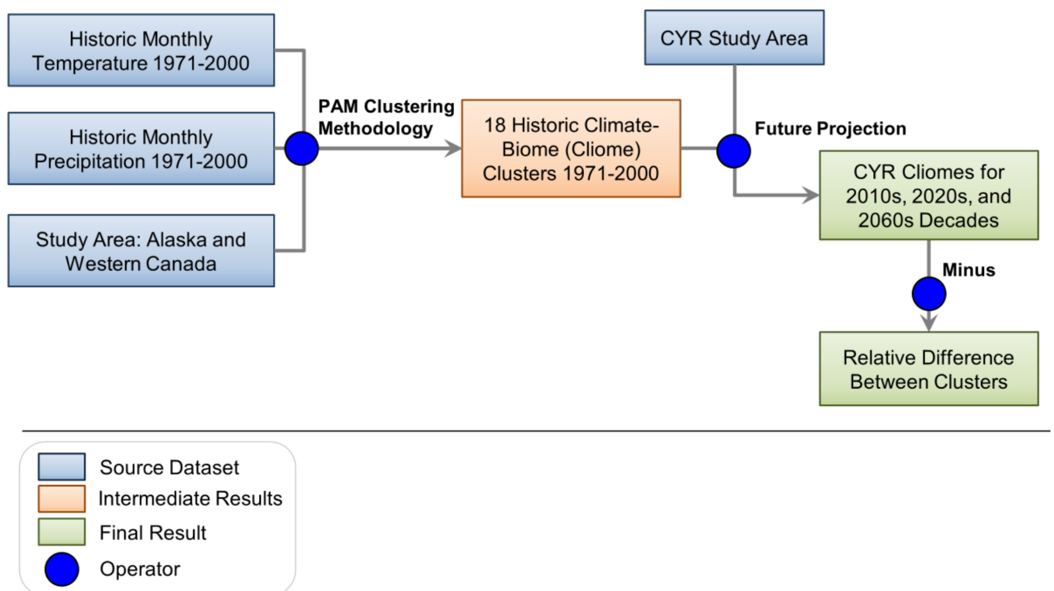

Figure 3. Process model for analysis of Climate-Biome (Cliome) Clusters.

Limitations

Uncertainty is inherent in all climate projections; much of this uncertainty is addressed by averaging multiple models across decades, but all projections must still be understood in the context of SNAP’s methodology. Climate data, while relatively fine-scale, do not always match the scale of phenomena that affect CEs. No direct data are available to link climate with water temperature, which limits the applicability of SNAP data to aquatic assessments. Moreover, available data do not always match, in scale or detail, the climate-related attributes and indicators most closely linked to particular Coarse-Filter or Fine-Filter CEs. Even when linkages between CEs and climate variables are relatively clear, the literature does not often provide precise information regarding threshold values. The cliomes model, although intended to suggest climate-induced stress to biomes or ecosystems, cannot be used as a proxy for biome shift or vegetation change.

Fire

Fire is both an integral ecosystem component and a key driver of change in Alaska. Warming climate is predicted to alter and shorten fire cycles, thereby changing vegetation patterns across the landscape. Increasingly, fire is also becoming a driver of change in tundra habitats, affecting species, such as caribou, that utilize these habitats.

Datasets

The modeled output representing percent burn and fire return interval is shown in Table 4.

Table 4. Summary of datasets for the fire CA.

Dataset Name	Data Source	Status
Projected (2006-2100) ALFRESCO outputs	Scenario Network for Alaska and Arctic Planning	Processed
Alaska Fire History datasets	BLM	Processed

Model Methods

Modeling and analysis of projected changes in fire pattern, fire frequency, and vegetation (with or without fire) can shed light on multiple aspects of future ecosystem function, including human/landscape interactions. Fire will be modeled using the Alaska Frame-based EcoSystem Code (ALFRESCO) model in the larger context of a projected future fire regime and its effects on major vegetation classes. Climate projections (as described above), past fire history, and current vegetation patterns will be used in part to model patterns of fire frequency across the landscape (Figure 4).

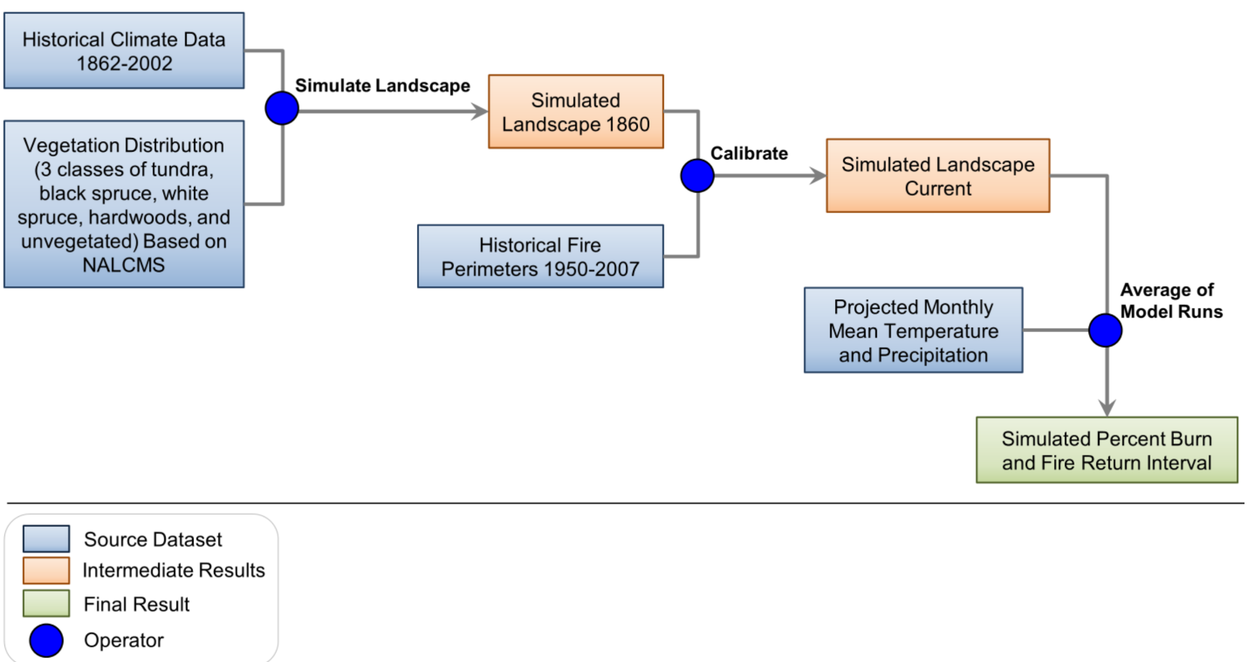

Figure 4. Process model for analysis of fire CA.

ALFRESCO simulates the responses of vegetation to cumulative climatic changes. The model assumptions reflect the hypothesis that fire regime and climate are the primary drivers of landscape-level changes in the distribution of vegetation in the circumpolar arctic/boreal zone. Furthermore, the model assumes that vegetation composition and continuity serve as a major determinant of large, landscape-level fires. ALFRESCO operates on an annual time step, in a landscape composed of 1 × 1 km pixels. The model simulates a range of ecosystem types, including three distinct types of tundra, black spruce forest, white spruce forest, deciduous forest, and grassland-steppe. SNAP climate data, as described above, will be included among the ALFRESCO inputs.

The "distribution" of varying fire frequencies is intimately tied to vegetation, as well as climate, but also involves stochastic elements such as the exact location of lightning strikes and the variability of weather patterns at finer time-scales than are available to modelers. Thus, multiple model runs yield varying results. Fire distribution per se will not be modeled; rather the model will project burn frequency and extent across the landscape to ultimately model changes in vegetation patterns and distribution. Outputs will include landscape-wide estimates of percent cover by type and age, projected average area burned per year across the target time periods (from the 2010s to the 2020s and from the 2010s to the 2060s), and fire return intervals on a regional and sub-regional basis. Sub-regions will be based on defining areas of similar fire ecology.

Limitations

No data are readily available to address the following fire-related variables, although some can be indirectly or qualitatively addressed:

- A wider range of cover types.
- Fine-scale calibration of shifts in cover types post fire.
- Direct ALFRESCO outputs for fire severity.
- ALFRESCO linkages and feedbacks with human use of the landscape, particularly human-caused fire starts and intensive fire suppression around communities and infrastructure.

These data gaps do not impede our ability to address fire as a CA. They do, however, somewhat affect the analysis of overlap between fire and CEs, in the sense that the Terrestrial Coarse-Filter CEs (Biophysical Settings) used in the REA do not precisely match the cover types used in ALFRESCO. However, the projected shifts in ALFRESCO vegetation classes will still analyzed both quantitatively and qualitatively. Although the REA is focused on broad scale landscape dynamics rather than highly localized impacts, when possible, expert input and literature review will be used to inform analysis of the relationship between land use, fire starts, and fire suppression.

Permafrost

Current permafrost conditions vary within the CYR Ecoregion. In most areas, permafrost is discontinuous, and warm enough that small temperature shifts may lead to extensive thawing. As such, permafrost is likely to be an important threshold variable in the CYR study area. Even in areas of continuous permafrost, active layer thickness varies on both a micro- and macro-level across the landscape. Small differences in active layer thickness and associated patterns of drainage can yield large differences in drainage patterns, land cover, and vegetation. As such, soil thermal dynamics represent both a CA and a CE in Arctic Alaska. For the purposes of the Central Yukon REA, we treat it as a CA.

Datasets

The main components of the permafrost model are represented in the Ecoregional Conceptual Model. Permafrost modeling will incorporate both SNAP climate projections and the Geophysical Institute Permafrost Lab (GIPL) permafrost model for Alaska, which relies on spatial data related to soil, vegetation, and climate. Outputs of the GIPL permafrost model that will be used for this assessment, mean annual ground temperature (MAGT) and active layer thickness (ALT), are summarized in Table 5 below.

Table 5. Summary of datasets for the permafrost CA.

Dataset Name	Data Source	Status
Mean annual ground temperature 2010s, 2020s, and 2060s (A2, 2 km grid)	Scenario Network for Alaska and Arctic Planning	Processed
Active layer thickness 2010s, 2020s, and 2060s (A2, 2 km grid)	Scenario Network for Alaska and Arctic Planning	Processed

Model Methods

The Geophysical Institute Permafrost Laboratory (GIPL) model was developed specifically to predict the effect of changing climate on permafrost. The GIPL model is a quasi-transitional, spatially distributed equilibrium model for calculating the active layer thickness (the thin layer above permafrost that seasonally freezes and thaws) and mean annual ground temperature. Inputs include data from the Global Land Cover Characteristics Database Version 2 Surface vegetation thermal properties; National Atlas of the United States of America, 1985 Organic matter and vegetation thermal properties; and USGS 1997 Surficial Geology Map of Alaska found on the Karlstrom (USGS 1964) statewide Alaska surficial geology map: soil thermal properties (Figure 5).

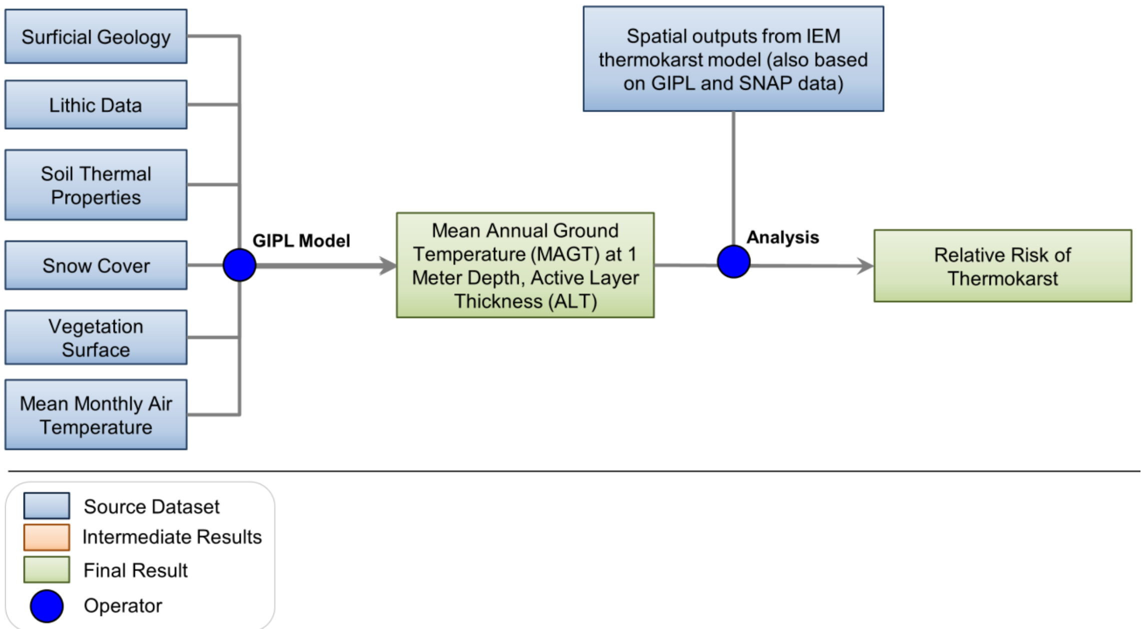

Figure 5. Process model for analysis of permafrost CA.

The GIPL permafrost model calculates permafrost extent, mean annual ground temperature, mean annual ground surface temperature, active layer thickness, snow warming effect, thermal onset from data inputs relating to the geologic and soil properties, effects of ground insulating snow and vegetation layers, and predicted changes in air temperature and annual precipitation. The primary outputs relevant to the CYR are the mean annual ground temperature (MAGT) at one meter depth and the active layer thickness (ALT). Active layer thickness represents two different outputs: the depth of seasonal (summer) thaw for areas with permafrost at one meter depth and the maximum depth of seasonal (winter) freezing for areas that are free of permafrost at one meter depth. Together, these properties delineate the presence and local extent of permafrost. The model is ground-truthed and validated using cores from around the state (GIPL 2013).

GIPL has also been working with SNAP partners and others on an Integrated Ecosystem Management project (IEM). Although not yet complete, the project has already offered some completed products, including spatial projections of thermokarst risk. These outputs can be used to augment the REA analysis.

Limitations

The GIPL permafrost model provides a general and coarse approximation of permafrost conditions across the landscape. Despite the best available ground-truthing and validation of the GIPL model, and despite the use of the most reliable available climate projections from SNAP data, uncertainty is inherent in climate models and in permafrost models, as well as in the linked modeling of climate-induced permafrost change and thermokarst. Fine-scale changes in permafrost micro-conditions at a scale of meters rather than kilometers cannot be accurately predicted by the GIPL model. For example, the GIPL model cannot predict the formation of specific thermokarst features or the drainage of specific lakes from permafrost thaw. However, the predicted changes in permafrost at the landscape level indicate where such phenomena will be most likely.

Invasive Species

Invasive species are included in this REA, as well as all other BLM REAs, due to their widespread capacity to disrupt ecological processes and degrade biological resources. While much of Alaska has not witnessed dramatic impacts of invasive species in natural systems, they are increasing in abundance, distribution, and ecological and economic harm (see Carlson and Shephard 2007, Schwörer et al. 2012). Non-native animal species, such as Norway rats, appear to be confined to urban residential areas and are not known to have established in natural areas within the Central Yukon study area. Non-native plant species are known from within and adjacent to the Central Yukon study area and have spread into natural and semi-natural habitats; we therefore focus the invasive species assessment on invasive plant species.

Datasets

AKNHP maintains a database of invasive plant species information, the Alaska Exotic Plants Information Clearinghouse (AKEPIC). The AKEPIC database will inform the analysis of the invasive species CA (Table 6).

Table 6. Summary of datasets for the invasive species CA.

Dataset Name	Data Source	Status
Alaska Exotic Plants Information Clearinghouse (AKEPIC)	Alaska Natural Heritage Program	Processed

Model Methods

Invasive species are defined here as those non-native plant species with invasiveness ranks of greater than 60 (i.e., “moderately to extremely invasive”; see Carlson et al. 2008). Non-native species that are not expected to cause substantial impacts to ecosystem function are thereby omitted. The analysis is concentrated into two theme areas: 1) what is the current state of invasive species in the Central Yukon study area and which areas and resources are most at risk, and 2) what is the predicted state of invasive species in the Central Yukon study area. The current state of invasive species will be addressed by summarizing known locations, densities, and diversities of non-native species in spatial and tabular form. Identifying areas of highest risk of invasion will be addressed by an analysis of the relationship of plant species invasion to environmental and anthropogenic variables more broadly in the state. Areas vulnerable to invasion within the study area can be identified by analysis of the landscape variables most associated with invaded areas elsewhere (see Carlson et al. 2014). Variables will include such things as growing season length, mean annual temperature, elevation, river length, etc. Anthropogenic variables will include such elements as human population density, road and trail densities, proportion of land devoted to industrial land-use, mean annual income, etc. The relationship of probability of infestation to the diverse predictor variables will be explored using Classification And Regression Tree (CART) analysis. Generating the areas of currently known invasive species and areas susceptible to invasion will allow an overlay of rare species and habitats of concern, and thereby highlight those CEs and locations that are at greatest risk. The second theme of future conditions will build from the relationships of invasive species abundance and diversity with the predictor variables, such that we can model future climate and development scenarios in the REA to identify those regions most susceptible to invasion (Figure 6). This approach was successfully employed in the Yukon River Lowlands – Kuskokwim Mountains – Lime Hills REA (Carlson et al. 2014).

In addition to the synthetic invasion vulnerability assessment described above, we propose to explore the vulnerability of streams and lakes to establishment of waterweed (*Elodea* spp.). Waterweed is currently established in the Central Yukon study area in Chena Slough, Chena River, and Chena Lake, and it is of substantial concern for aquatic resources (Nawrocki et al. 2011). Waterbody vulnerability will be assessed by reviewing current associations of waterweed locations in the state with potential explanatory variables, such as proximity to roads, boat launches, waterbody depth and size, etc. Because current waterweed infestations are highly spatially auto-correlated we will likely not be able to employ a classification tree modeling approach as outlined above or presented in Tamayo and Olden (2014). However, we can identify those waterbodies that have combinations of traits that appear to make them susceptible to invasion based on current patterns, literature review, and common sense. For example, slow-moving, clear-water waterbodies that cross roads or have public access could be expected to be at high risk for establishment of waterweed.

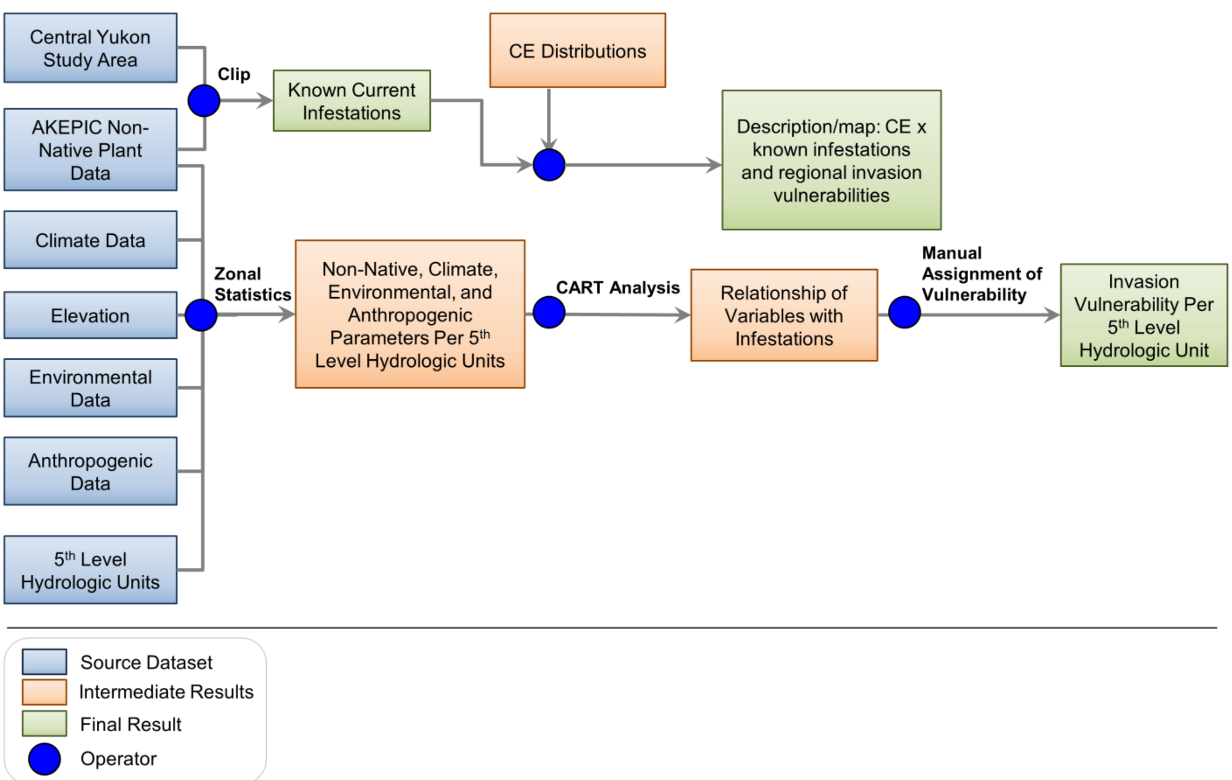

Figure 6. Process model for analysis of invasive species CA.

Limitations
Survey points for invasive plants are not random and many species have only recently been introduced to the state; therefore, it is possible that documented locations do not represent the true breadth of a particular species climate niche space. Additionally, the probability of invasive species establishment is largely driven by anthropogenic variables, such as population size and road density, elsewhere in the state. Individual invasive species responses may be obscured by including all species together. However, we can model individual species with sufficient number of locations to gauge the variability among species. The study area lacks a fine scale soil or substrate data layer that could provide mechanistic information regarding establishment potential.

Identification of waterbodies vulnerable to invasion by waterweed is limited by few known locations in the state, limited survey effort, and limited spatial layers for aquatic variables.

Insects and Disease

Insect and disease agents will be analyzed as a CA for the Central Yukon REA, but only in the current time scenario. Future areas of vulnerability will not be modeled because the nature of insect and disease outbreaks is too stochastic and the relationship of outbreaks with other CAs is too imprecisely understood. However, historic (past 25 years) and current (past 5 years) distributions of insect and disease damage areas will be provided, and short-term future trends can be inferred by comparing the two.

Datasets
Data use for the analysis of forest areas damaged by insect and disease agents is summarized in Table 7.

Table 7. Summary of datasets for the insects and disease CA.

Dataset Name	Data Source	Status
Aerial Damage Survey Alaska 1989	USGS Forest Health Monitoring Clearinghouse	Processed
Aerial Damage Survey Alaska 1990	USGS Forest Health Monitoring Clearinghouse	Processed
Aerial Damage Survey Alaska 1991	USGS Forest Health Monitoring Clearinghouse	Processed
Aerial Damage Survey Alaska 1992	USGS Forest Health Monitoring Clearinghouse	Processed
Aerial Damage Survey Alaska 1993	USGS Forest Health Monitoring Clearinghouse	Processed
Aerial Damage Survey Alaska 1994	USGS Forest Health Monitoring Clearinghouse	Processed
Aerial Damage Survey Alaska 1995	USGS Forest Health Monitoring Clearinghouse	Processed

Dataset Name	Data Source	Status
Aerial Damage Survey Alaska 1996	USGS Forest Health Monitoring Clearinghouse	Processed
Insect Damage Survey Explorer Alaska 1997 to 2012	USFS Forest Health Protection Insect Damage Survey Explorer	Processed
Aerial Damage Survey Alaska 2013	Tom Heutte, USFS State & Private Forestry	Processed
Aerial Damage Survey Alaska 2014	Tom Heutte, USFS State & Private Forestry	Processed
Insect Damage Survey Explorer Alaska Flight Paths 1999 to 2012	USFS Forest Health Protection Insect Damage Survey Explorer	Processed
Aerial Damage Survey Flight Paths 2013	Tom Heutte, USFS State & Private Forestry	Processed
Aerial Damage Survey Flight Paths 2014	Tom Heutte, USFS State & Private Forestry	Requested

Model Methods

The United States Department of Agriculture (USDA) conducts annual aerial forest damage surveys using fixed-wing aircraft along predetermined routes across Alaska's forests, with up to 25% of the total forested area surveyed each year. Insect damage within one to two miles on either side of the flight path is recorded by drawing polygons onto 1:250,000 scale USGS topographic maps or a digital elevation model (FS-R10-FHP 2012, 2013). Damage observed has been attributed with severity in three categories: high, moderate, and low.

Insect and disease outbreaks from 1989 to 2014 will be identified within the Central Yukon study area by standardizing and compiling the available U.S. Forest Service (USFS) Region 10 aerial forest damage survey datasets and removing polygons for forest damage caused by agents other than insects or diseases (i.e., abiotic agents such as fire, flooding, and windthrow).

The Aerial Damage Survey datasets for years 1989 to 1996 will be merged, retaining only those fields that are common to all the datasets. An attribute table of standardized fields and values will be created manually. A cleaned and standardized version of the attribute table that was downloaded with the Insect Damage Survey Explorer 1997 to 2012 geodatabase attribute table will be created manually for the Insect Damage Survey Explorer 1997 to 2012 dataset. Two attribute tables will be created manually to standardize the Aerial Damage Survey 2013 and 2014 datasets. These standardized datasets will be merged into a single dataset covering all surveyed areas in Alaska from 1989 to 2014 (Figure 7).

Abiotic damage areas will be deleted from the merged dataset: flooding, none, fire, slide/avalanche, windthrow, and winter injury. The only biotic damage type that will be deleted is porcupine. Forest damage will be clipped to the Central Yukon study area and shown for the past 25 years (1990 to 2014) and the past 5 years (2010 to 2014).

The total surveyed area within the Central Yukon study area will be calculated by standardizing and merging the Insect Damage Survey Explorer Alaska Flight Paths 1999 to 2012 dataset with the Aerial Damage Survey Flight Paths 2013 and 2014 datasets. The percent of total area surveyed will be based on an assumed 2 mile radius of observation from the flight path.

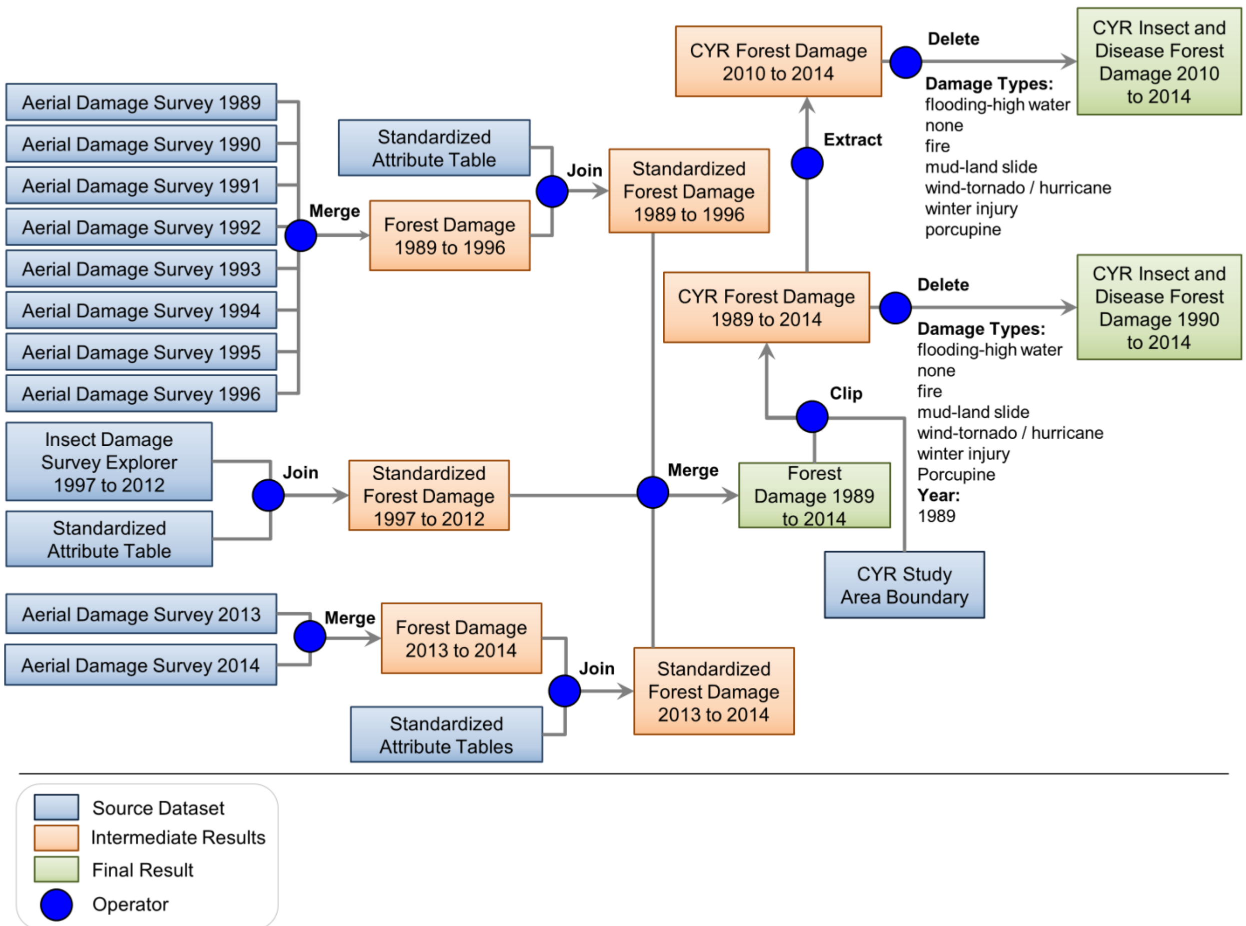

Figure 7. Process model for analysis of insect and disease CA.

Limitations

Surveys have concentrated along riparian corridors in the past, leaving areas far from major rivers under-sampled. Smaller forest patches and mixed shrub and forest habitats are also likely under-sampled. Some areas are surveyed annually while others are rarely or have never been surveyed. Additionally, no more than 25% of the forested area is surveyed during a single year, so data from any single year provides an incomplete synopsis of trends in the status of insect and disease agents (FS-R10-FHP 2012, 2013).

Forest damage is determined by aerial detection surveys during which an observer sketches observed damage areas onto a map. Time, money, and the interpretation of the observer all influence the data collected and the areas mapped. Many of the observations are not ground-truthed because of the limitations of time and money. Some insect and disease agents are not readily detectable by aerial survey. However, aerial detection surveys currently provide the most efficient and effective method to monitor forest health in Alaska (FS-R10-FHP 2012, 2013).

Anthropogenic Uses

The CYR study area spans a very large area with a diverse set of human activities. While much of the region is remote and sparsely inhabited, the Fairbanks North Star Borough (FNSB) area, and the communities along the Alcan Highway are much more accessible and are well connected to Canada and the rest of the United States. While the human footprint in most of the region is minimal, development along the Alcan Highway and in the FNSB reflect the population density of these areas and the attractions they hold for tourists during the summer months.

Anthropogenic uses in the region include urban growth around Fairbanks, several mining and other resource development activities, energy development, transportation infrastructure in and originating from the FNSB area, recreation activities, and subsistence. While most oil and gas exploration is on the North Slope just north of the CYR study area, Fairbanks is the closest urban center, well connected with the rest of the world. Thus, Fairbanks serves as an industrial base camp for much of the supply chain and management infrastructure for the North Slope industrial concerns. In addition, Fairbanks is also the transportation and service hub for much of the CYR study area. Many smaller communities depend on Fairbanks for services. Many state and federal offices, three military bases, the University of Alaska Fairbanks, comprise the large public enterprises.

Hunting and fishing are major recreational activities in the region, and the impact of these activities is significant in densely populated areas. Subsistence plays a significant role in the social and economic aspects of the remote rural communities in the region. Management of natural resources between subsistence and non-subsistence uses is of high importance.

Datasets

A primary product of the REA process is to assess the current and future human footprint in the region. Spatial data relevant to constructing human footprint includes community footprints from the U.S. Census Bureau, transportation infrastructure from the Alaska Department of Transportation (AKDOT), subsistence use areas from the Alaska Department of Fish and Game (ADF&G), recreational areas from various state and federal agencies, natural resource extraction elements such as mines from the Alaska Department of Natural Resources (ADNR), and energy infrastructure from the Alaska Energy Authority (Table 8).

- *Community Boundaries*: US Census TIGER files will be used for community boundaries. However, there may be some communities in the region where we might digitize the community footprint.
- *Transportation*: Datasets on transportation include roads, trails, river transportation routes, and infrastructure facilities such as docks and airports. Alaska Department of Transportation is the source for most of this information. Although, the Bureau of Land Management (BLM), Federal Aviation Administration, Fairbanks North Star Borough, and several other federal, state,

regional, and local agencies may have relevant data. Some of this data is available in spatial, digital form.

- *Mining*: ADNR will be the source for all hard rock mine site locations, associated foot print, and their ancillary infrastructure. ADNR also keeps track of past mines and reclaimed sites. Data on potential mines may be difficult to obtain. The United States Geological Survey (USGS) keeps track of all the placer mining location through their Alaska Resource Data File (ARDF). This information will be used to identify current, past, and potential placer mining activity.
- *Subsistence Use Areas*: Out of the 67 communities in the region, subsistence use area data is available for only 12 communities. This data is obtained from ADF&G, collected through their household subsistence surveys. In addition to this, there may be other agencies that may have subsistence use area information for this region. Much of such data is limited in time and geography and may not be comprehensive.
- *Recreation*: All national and state parks, preserves, and other restricted areas that may be open for recreation will be included. Much of this spatial data is available from various national and state sources.
- *Commercial fishing and sport hunting*: The ADF&G Commercial Fishing Division and the Commercial Fisheries Entry Commission are the primary sources for data on fishing. There is very little commercial fishing in the interior of Alaska, and much of it has been shut down during recent years. However, several residents in the region hold commercial fishing licenses. There is no commercial hunting in the region. Sport hunting is common, and data is available at a GMU level from ADF&G.
- *Military*: Military area boundaries are available from the US Census.
- *Energy Development:* Locations of current and planned energy infrastructure are available from the Alaska Energy Authority.

In addition to the human footprint, the REA process also answers specific questions concerning human activities. This requires data on several social, economic, demographic, and cultural attributes of the population. Data for some of these indicators are not always available or accessible. For example, there is no data source for self-employed fishermen, which make up a large share of local workers. Employment data from the Alaska Department of Labor only include wage earners. Other data, such as subsistence harvests, only cover a subset of all the communities within the study area.

Table 8. Summary of datasets for the anthropogenic CA.

Dataset Name	Data Source	Status
Total population	U.S. Census, AK DOLWD	Obtained
Population by sex by age group	U.S. Census	Obtained
Borough/census area migration	AkDOLWD	Obtained
Renewable energy project	AEA, AEDG	Obtained

Dataset Name	Data Source	Status
Renewable energy potential	AEA	Obtained
Mining activities	ARDF	Obtained
Distressed communities	Denali Commission Alaska	Obtained
Community gasoline prices	DRCA Research and Analysis Section	Pending
Fuel oil price	Alaska Energy Gateway	Obtained
Alaska fuel price projections 2014-2040	ISER	Obtained
School enrollment	EED, NCES	Obtained
Sport game harvest	ADF&G	Pending
Commercial and subsistence salmon harvest	ADF&G	Pending
Historic maps, aerial photos of communities	DCRA	N/A
Alaska fishery management report	ADF&G	N/A
Subsistence harvest	ADF&G, CSIS (Community Subsistence Information System)	Obtained
Native allotments	NSB	Obtained
Borough and census area boundary files	NSB	Obtained
ALARI	AkDoLWD	Obtained
PFD	DoR	Pending
Supplemental Nutrition Assistance Program (SNAP)	US Census Bureau	N/A
Renewable Energy geodatabase	AEA	Obtained
Planned & Proposed Infrastructure	AkDoT	Obtained
Anadromous Streams	ADF&G	Obtained
General Land Status	BLM/DNR	Obtained
State Parks	ADNR	Obtained
Federal Mining Claims	BLM	Obtained
Placer Districts	USGS	Obtained
State Mining Claims	ADNR	Obtained
State Mining Prospects	ADNR	Obtained
Red Dog mine, port, road	ADNR, DoT	Pending
Ft Knox mine footprint	ADNR	Pending
Pogo mine footprint	ADNR	Pending

Dataset Name	Data Source	Status
Usibelli mine footprint	ADNR	Pending
Transportation Infrastructure	USGS, AkDoT, ADNR, ADF&G, ISER	Obtained
Road from Noatak to deLong road	AkDOT	Pending
Kivalina evacuation road	AkDoT	Pending
Road to ambler district	AkDOT	Pending
NWAB trails	NWAB	Obtained
NWAB subsistence use areas	NWAB	N/A
NWAB sensitive ecological areas	NWAB	N/A
NWAB Resource Development Opportunity Areas (RDOA)	NWAB	N/A
DEC contaminated sites database, including abadoned military sites	ADEC	Obtained
Cape Blossom road and port site	ADEC	Pending

Model Methods

Spatial data layers, where available, will be acquired, cleaned, and compiled into one composite layer for the human footprint (Figure 8). Social and economic data will be summarized and patterns identified. Much of the social and economic data is geocoded, and will be represented spatially. Where it is impossible to spatially represent data, tabular data will be provided.

While current human footprint is built from carefully combining various human activities into a meaningful composite, future human footprint relies heavily on judging the potential and possibility of various activities. Each anthropogenic activity's future trajectory differs and is dependent on government policies, public perceptions, market potential, and physical possibility. Accuracy of future human footprint depends on information available to adequately judge any human activity using these four criteria. For example, potential for a road connecting Nome to the rest of the state's road system depends on public's perception of the need and associated risks for such a road. Policy dictating new road corridor will heavily depend on the economic costs of constructing and maintaining such a road, in addition to political considerations. The economic considerations will depend on the market's ability to sustain the associated costs. Such predictions are best done using a scenario planning exercise. Since the REAs are not structured to accommodate such an exercise, assessing future human print will be heavily limited by the available information.

Thus, criteria will be identified for each major anthropogenic activity (mining, transportation, energy infrastructure, natural resource extraction, recreation, and subsistence) to assess future human footprint in both 2025 and 2060. Following criteria will be used:

- Mining: ARDF is the principal source of placer mining data. In order to identify potential placer mines, we will identify all placer mines that were active less than 10 years ago, and were located within an active mining claim. We determined that these placer mines have the potential of being mined in the future. In the case of hard rock mines, an application for permitting was used as a criterion for identifying potential mine in the near time (2025), and a mineral lease or mining claim will be used for longer term (2060). The AMT suggested we identify mines based on APMA descriptions. All attempts will be made in identifying as suggested. We will consult with the AMT if this effort is beyond the scope of this project. Potential contamination associated with mining will be identified by location. The extent of potential contamination is

- Transportation infrastructure: For a transportation project such as a road, a barge landing, or an airport, following criteria will be used:

    - Possible for 2060: If the project is in any stage between money appropriated for exploration to an environmental impact statement (EIS) prepared for public review. Media speculations on a proposed or potential project will not be considered.

    - Possible for 2025: If the project is past the EIS stage, and a viable alternative is identified.

- Energy Infrastructure: All energy infrastructure that were approved by the Alaska Energy Authority (AEA) to be constructed will be identified in the near term (2025). All those infrastructure that were either under consideration or were rejected by AEA will be identified in the long-term (2060). The rejected plans are often reconsidered in a shorter time span than the 45 years leading up to this projects long-term (2060) marker in time.

- Natural resource extraction: This includes commercial fishing and hunting; oil and gas extraction, and gravel mining. No commercial hunting activity exists in CYR region. The region was closed for commercial fishing for several years over the last decade. However, to the extent possible, commercial fishing activity will be projected for both near and long term. CYR region does not have any active oil and gas leasing at this time. Parts of this region are open for exploration. Only one exploration permit in North Nenana was applied for by Doyon Ltd., and it is pending approval. Gravel mining operations are associated with almost every development activity. Thus, any future (near or long term) activity will be associated with gravel mining, and will be identified as such.

- Recreation: None of the parks, preserves, or other recreational areas keep any records of visitors, and thus it is impossible to predict park usage with administrative records. Such predictions are usually based on visitor surveys. Information will be obtained where possible.

- Subsistence: Data available from ADF&G will be used to the extent possible, to predict both the near and long term levels of subsistence harvest. However, this data is severely limited for use in projections.

We will explore urban growth modeling to assess the expansion of urban growth by 2025 and 2060 in the Fairbanks North Star Borough. Based on our experience in working with social, demographic, and economic data, we may be severely limited in our abilities to adequately use the techniques.

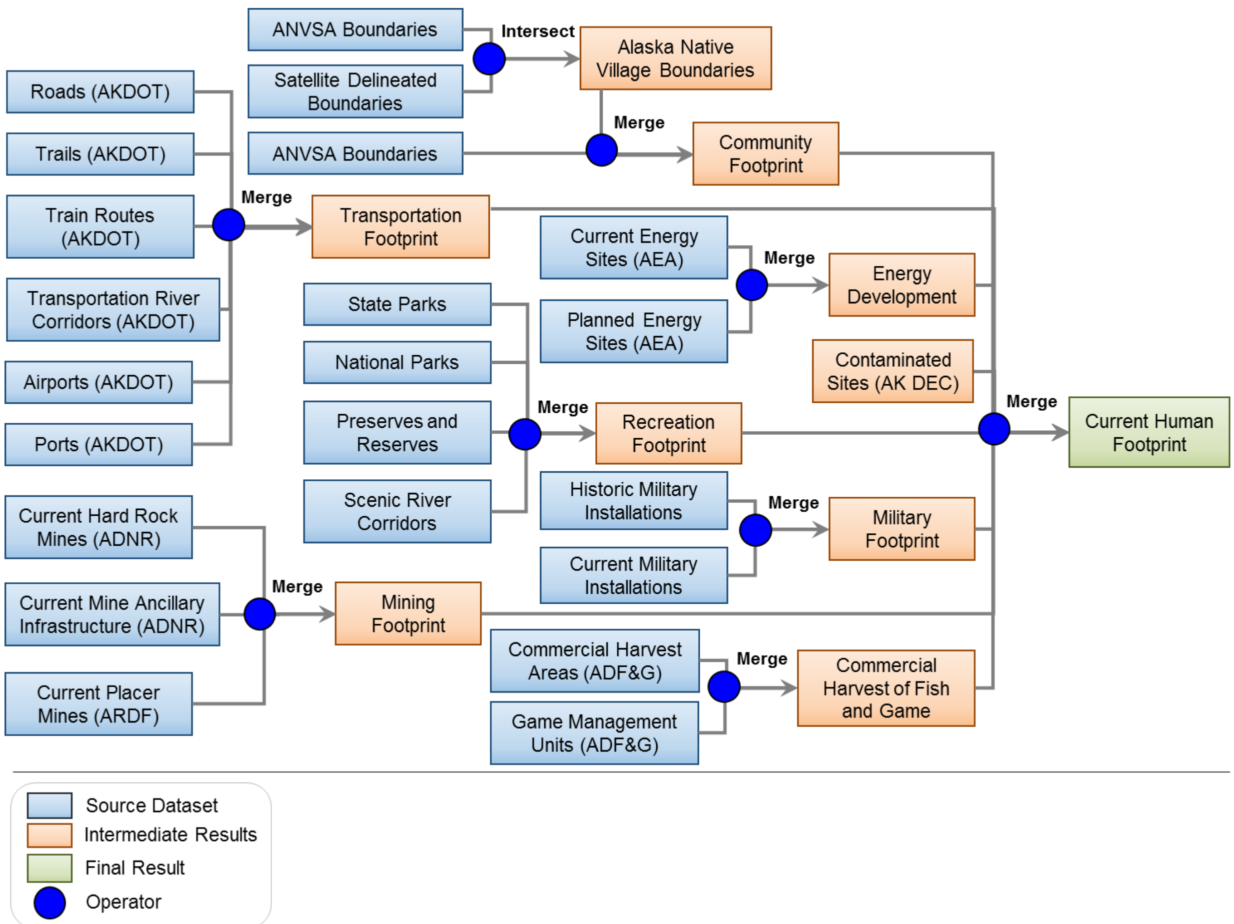

Figure 8. Process model for analysis of human footprint.

Limitations

Limitations on producing a comprehensive current, past, and future human footprint are all related to the limitations on availability or accessibility of related data. Each set of data has distinct set of limitations. Predicting future human foot print, specifically through urban growth modeling techniques, is heavily dependent on availability of data on a variety of indicators including those listed below.

- *Community Boundaries*: The US Census TIGER files' boundaries are quite large relative to the community foot prints. While some of the boundaries may reflect the jurisdictional extent of the community, it is not entirely clear in many other cases. This relatively large footprint inflates the impact of the community on the environment.

- *Transportation*: We found that the roads and trails data is not always comprehensive or sometimes inaccurate. There is very little data on traffic counts, of most transportation routes. This makes it challenging to adequately assess the possible impacts of a particular transportation route on the environment.
- *Mining*: There are several limitations with the ARDF datafile. Primarily, the dataset is updated in a random fashion, and the updates may not be reliable. All the limitations will be explained in the final report.
- *Subsistence Use Areas*: Data available is just for the most recent year. ADFG does not have digital information for on subsistence use areas for past years. Therefore, the analysis will be limited to just one year.
- *Recreation*: While the geographic extent and much information about the natural assets of the parks and preserves is available, very little data is available on the visitor statistics of these facilities.
- *Commercial fishing and sport hunting*: While some data is available, most of it is coarse, and hunting location data is not accessible from ADFG.
- *Contaminants*: Contaminants are not considered a major anthropogenic factor with impacts at a regional level. Most sources of contamination are localized. Most contamination in the region is associated with current and potential mining, oil and gas extraction activities. Therefore, we will include a layer identifying locations of contamination (at various stages – active, cleaned, etc.) as part of the human footprint, but will not treat contaminants as a change agent.

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Chapter 2: Conservation Elements

CEs are defined as biotic constituents (e.g., wildlife and plant species or assemblages) or abiotic factors (e.g., soils) of regional importance in major ecosystems and habitats across the ecoregion. Selected CEs are meant to represent key resources in the ecoregion and may serve as surrogates for ecological condition across the ecoregion. Conservation elements were identified through the MQs and/or were derived from the Ecoregional Conceptual Model to ensure the integration of practical management concerns with current scientific knowledge.

Coarse-Filter CEs

Terrestrial and Aquatic Coarse-Filter CEs represent the dominant ecological patterns of the ecoregion. Coarse-filter CEs include regionally significant terrestrial vegetation types and aquatic ecosystems within the assessment area. They represent the habitat requirements of most characteristic native species, ecological functions, and ecosystem services.

Terrestrial Coarse-Filter

Terrestrial Coarse-Filter CEs are regionally important vegetation types that represent the dominant ecological patterns of Central Yukon study area. They adequately address the habitat requirements of most characteristic native species, ecological functions, and ecosystem services.

To select CEs for the project area, we identified the dominant alpine, upland, lowland, and riparian vegetation types that characterize the region. Each CE represents a biophysical setting that can be defined by a characteristic suite of ecological site characteristics such as disturbance processes, vegetation succession, and generalized soil characteristics. Adopting this approach for the region will allow us to more effectively evaluate the impacts of the selected Change Agents on vegetation pattern and composition.

Terrestrial Coarse-Filter Conservation Elements:

1. Alpine Dwarf Shrub Tundra
2. Alpine and Arctic Tussock Tundra
3. Upland Mesic Spruce-Hardwood Forest
4. Upland Mesic Spruce Forest
5. Upland Low Shrub Tundra
6. Lowland Woody Wetland
7. Floodplain Forest and Shrub

We reviewed these classes using existing source maps in an effort to determine the best source for each CE. Two statewide landcover maps provide adequate information from which to derive CEs 1-6: The National Landcover Database (Homer et al. 2004; referred to in this document as NLCD), and the Northern, Western, and Interior Alaska Landcover Mosaic (Boggs et al. 2014; referred to in this document as the Alaska Vegetation Mosaic, or AKVM). In order to delineate Floodplain Forest and Shrub, we will use the floodplain boundary delineated within the Surficial

Geology map embedded within the Alaska Permafrost Map (Jorgenson et al. 2008). The Circum-boreal Vegetation Map (CAFF 2011) has not yet been made available for use; however, should it be released within timeline of the REA, we will assess the map products and determine whether or not to incorporate the dataset into the CE distribution maps.

Datasets
Datasets for the creation of CE distribution maps are outlined in Table 9.

Table 9. Summary of datasets for Terrestrial Coarse-Filter CEs.

Dataset Name	Data source	Status
Vegetation Map of Northern, Western, and Interior Alaska	Alaska Natural Heritage Program	Obtained
National Landcover Database	Multi-Resolution Land Characteristics Consortium	Obtained
Surficial Geology of Alaska	Alaska Permafrost Map	Obtained
Circumboreal Vegetation Map	Conservation of Arctic Flora and Fauna	Not Released

Distribution Model Methods
The source map and associated map classes that we propose using to delineate each Terrestrial Coarse-Filter CE are outlined in Table 10.

Table 10. Proposed source map for each Terrestrial Coarse-Filter CE.

Coarse-Filter CE	Source Map	Map Classes
Alpine Dwarf Shrub Tundra	AKVM	Dwarf Shrub; Dwarf Shrub Lichen
Alpine & Arctic Tussock Tundra	AKVM	Tussock Shrub Tundra; Graminoid Tussock
Upland Mesic Spruce-Hardwood Forest	NLCD	Needleleaf-Deciduous Forest; Deciduous Forest
Upland Mesic Spruce Forest	NLCD	Needleleaf Forest
Upland Low Shrub Tundra	AKVM	Low Shrub; Low Shrub/Lichen; Low willow
Lowland Woody Wetland	NLCD	Woody Wetland
Floodplain Forest and Shrub	Surficial Geology 2008 and NLCD	Needleleaf Forest, Needleleaf-Deciduous Forest, Deciduous Forest, Shrub/Scrub

Limitations
The landcover maps used to develop the CE distributions have inherent limitations. The reported overall accuracy for the interior boreal portion of the NLCD map is 63.9% (Selkowitz and Stehman 2011), and the mosaicked map produced by AKNHP (Boggs et al. 2014) is compiled from maps of varying accuracies. For example, the maps produced by Ducks Unlimited generally report accuracies ranging from 65-80%, however, many of these are based on old satellite imagery and are now out-of-date. Several of the maps produced by the National Park Service do not have reported accuracies.

Neither landcover map provides an adequate depiction of all of the selected CEs. NLCD provides a more consistent depiction of forest and forested wetlands, but AKVM provides a better depiction of the non-forested landcover classes. While it would be preferable to derive all of the classes from the same landcover map, the limitations of the NLCD non-forest mapping would create some issues for describing and interpreting vegetation pattern and response to change agents.

Specific limitations in NLCD non-forest map classes:

<u>Alpine Dwarf Shrub Tundra CE</u>

Equivalent NLCD class is Dwarf shrub. This class is satisfactory for the central portion of the study area, but in western region, vast areas of Tussock Tundra are mapped as Dwarf Shrub in NLCD.

<u>Alpine & Arctic Tussock Tundra CE</u>

Equivalent NLCD class is Sedge/Herbaceous; however much of the area mapped as tussock in the AKVM source maps is mapped as either Shrub/scrub or Dwarf Shrub in NLCD. (Criteria for Sedge/Herbaceous class is at least 80% graminoid or forb; other Alaska classifications use a much lower threshold.)

<u>Upland Low Shrub Tundra CE</u>

The NLCD class Shrub/Scrub is broad landcover class which includes all non-wetland woody vegetation > 20 cm tall and < 5 m tall. Upland Low Shrub Tundra is included within the Shrub/Scrub NLCD class, also see above comment on tussock tundra.

In order to provide the best available CE models for the region, we suggest extracting selected classes from the NLCD for forested classes and the AKVM for non-forested classes.

Aquatics Coarse-Filter

Four habitat types were selected as Aquatic Coarse-Filter CEs for the CYR REA. An effort was made to select habitats representative of regionally significant ecological patterns. For example, large connected lakes represent important spawning, overwintering, and summer foraging habitats for fish species.

1. Rivers and Large Streams
2. Small Streams (including headwater streams)
3. Large Connected Freshwater Lakes
4. Small Connected Freshwater Lakes

Datasets

The CYR REA study area lacks the aquatic habitat map necessary to define Aquatic Coarse-Filter CEs by habitat. Instead, Aquatic Coarse-Filter CEs will represent several common categories of water bodies defined by the National Hydrography Dataset (NHD). The NHD is the best available spatial data of aquatic resources for the REA study area (Table 11). It is a digital representation of the stream network and lakes shown on USGS topographic maps, which were created from historic aerial photos. It has several limitations:

a. The NHD underrepresents small streams because they are often masked by vegetation cover and not visible in aerial photography.
b. The NHD is very outdated (most topographic maps were created in the 50's and 60's) and stream locations and lake areas have likely changed due to natural hydrologic disturbances and climate change.

Table 11. Summary of datasets for Aquatic Coarse-Filter CEs.

Dataset Name	Data Source	Status
National Hydrography Dataset (NHD): Waterbodies	USGS	Obtained
National Hydrography Dataset (NHD): Flowlines	USGS	Obtained
National Elevation Dataset (NED): Raster Grid	USGS	Obtained

Distribution Map Methods

Large and small connected lakes will be identified using the NHD and differentiated based on the definition used in Arp and Jones (2009) to differentiate small (< 0.1 km^2) from medium and large lakes (> 0.1 km^2) in the Geography of Alaska Lake Districts. Lakes that intersected the streams dataset will be created by intersecting with NHD flow lines.

The NHD is not attributed with stream order data. The best available Digital Elevation Model (DEM) for the study area is the National Elevation Dataset (NED;60 m pixels). Due to the limitations of the NHD, stream habitats will be mapped by creating a stream network from the DEM and TauDEM software using GIS. The TauDEM generated stream network is attributed with stream order and flow accumulation data that are not available in the current NHD. Thus, we will be able to identify headwater streams (1st and 2nd order streams that lack streams flowing into them), small streams (all other 1st and 2nd order streams), large streams (3rd order and higher streams), and named rivers (based on data obtained from the NHD).

Limitations
The NHD is the best available spatial data of aquatic resources for the CYR REA, but is outdated and cannot be used as an accurate representation of current waterbodies.

The lack of a statewide aquatic habitat classification represents a huge **data gap** that could be preventing more effective management of aquatic habitat resources. This is especially important given the spatial inaccuracies and limited attribute information in NHD that can be used to map aquatic habitats.

Limited information exists for specific threshold effects of attributes and indicators for Coarse-Filter CEs. Currently there are no climate change predictions specific to aquatic habitats, such as changes to water temperature or hydrologic regime.

Fine-Filter CEs

Fine-Filter CEs represent species that are critical to the assessment of the ecological condition of the Central Yukon study area for which habitat is not adequately represented by the Coarse-Filter CEs. Fine-Filter CEs selected for the Central Yukon REA are represented by regionally significant mammal, bird, and fish species.

Terrestrial Fine-Filter CEs

Seven species were selected as Terrestrial Fine-Filter CEs for the Central Yukon REA. An effort was made to select species representative of different ecological niches. For example, trumpeter swan broadly represents waterfowl resources for the REA.

1. Caribou (*Rangifer tarandus*)
2. Dall's sheep (*Ovis dalli*)
3. American beaver (*Castor canadensis*)
4. Snowshoe hare (*Lepus americanus*)
5. Golden eagle (*Aquilia chrysaetos*)
6. Gray-cheeked thrush (*Catharus minimus*)
7. Trumpeter swan (*Cygnus buccinator*)

Datasets

Data used for the analysis of Terrestrial Fine-Filter CEs are presented in Table 12.

Table 12. Summary of datasets for the Terrestrial Fine-Filter CEs.

Dataset Name	Data Source	Status
Alaska GAP Analysis terrestrial vertebrate occurrence database – Dall's sheep	Alaska Natural Heritage Program	Obtained
Alaska GAP Modeled Habitat Distribution of Dall's Sheep	Alaska Gap Analysis Project	Obtained
Dall's sheep occurrence points – Gate of the Arctic NPP, Noatak NP, Kobuk Valley NP.	National Park Service	Obtained
Dall's sheep occurrence points – Tanana Hills-White Mountains	US Fish and Wildlife Service	Obtained
Alaska GAP Analysis terrestrial vertebrate occurrence database – American beaver	Alaska Natural Heritage Program	Obtained
Alaska GAP Modeled Habitat Distribution of American beaver	Alaska Gap Analysis Project	Obtained
Beaver cache survey points - Kanuti NWR (report)	US Fish and Wildlife Service	Obtained
Alaska GAP Analysis terrestrial vertebrate occurrence database - Snowshoe hare	Alaska Natural Heritage Program	Obtained
Alaska GAP Modeled Habitat Distribution of Snowshoe hare	Alaska Gap Analysis Project	Obtained
Alaska GAP Analysis terrestrial vertebrate occurrence database - Golden eagle	Alaska Natural Heritage Program	Obtained
Alaska GAP Modeled Habitat Distribution of Golden eagle	Alaska Gap Analysis Project	Obtained
Golden eagle nest sites in Tanana Hills	BLM	Pending
Alaska GAP Analysis terrestrial vertebrate occurrence database - Gray-cheeked thrush	Alaska Natural Heritage Program	Obtained
Alaska GAP Modeled Habitat Distribution of Gray-cheeked Thrush	Alaska Gap Analysis Project	Obtained

Dataset Name	Data Source	Status
Alaska GAP Analysis terrestrial vertebrate occurrence database - Trumpeter swan	Alaska Natural Heritage Program	Obtained
Alaska GAP Modeled Habitat Distribution of Trumpeter swan	Alaska Gap Analysis Project	Obtained
Trumpeter swan summering habitats 2010 - Survey strata (report)	US Fish and Wildlife Service	Obtained
Habitat Management Guide - Caribou Ranges	Alaska Department of Fish and Game	Obtained
Seasonal range polygons of all caribou herds in Alaska	Alaska Department of Fish and Game	Obtained
Space use and habitat selection of Hodzana Hills and Ray Mountain caribou herds (report)	Horne et al 2014	Obtained
Caribou occurrence points, Kanuti NWR (report)	Craig and Benson 2012	Obtained
Western Arctic caribou herd - Winter kernal range of the	National Park Service	Pending
Western Arctic caribou herd - Calving ground kernal analysis (report)	Alaska Department of Fish and Game	Pending
Western Arctic caribou herd - fall migration routes (report)	Alaska Department of Fish and Game	Pending
Porcupine caribou herd - Satellite/radio collar data	Alaska Department of Fish and Game	Pending
40-Mile caribou herd - radio collar data	BLM/ADF&G	Pending
White Mountains caribou herd - telemetry data	BLM	Pending

Distribution Models Methods

Our goal is to generate a distribution map for each CE using existing datasets. For most CEs, existing distribution models were available from the Alaska Gap Analysis Project. Alaska Gap (AKGAP) models are spatial representations of a species predicted distribution, within known range limits, at 60 m pixel resolution. Models were generated through a combination of deductive and inductive modeling techniques (Gotthardt et al. 2013), and have been statistically assessed for accuracy and peer reviewed. It is important to note that the AKGAP models were developed to depict the species (CE) distribution across its full range in Alaska, not specifically within the CYR REA boundary. Although the distribution models were designed to be used for large-area resource management planning, we cannot guarantee the accuracy of the models once they are constrained by (clipped) to the CYR REA boundary. In an effort to establish that the models are suitable at the scale of the CYR REA, we are also compiling existing occurrence datasets to perform an independent accuracy assessment of each model that is specific to the REA. The AKGAP models will be clipped to the CYR REA boundary and then assessed for accuracy using presence (occurrence) data and randomly generated pseudo-absences that will be overlaid with model outputs to calculate classification success.

If accuracy assessment values are acceptable, we intend to use AKGAP distribution models for American beaver, snowshoe hare, gray-cheeked thrush and trumpeter swan. If not acceptable, distribution will be represented by the synthesis of occurrence data gathered for each species to generate assessment datasets. For raptors, the AKGAP distribution models are generally of poor quality as cliff nesting features were not mapped well. Therefore, the distribution of golden eagle will be mapped using existing occurrence data. For Dall sheep, a new distribution will be created by overlaying sheep radio collar occurrence points with the Vegetation Map of Northern, Western, and Interior Alaska (Table 9, AKNHP). The top five landcover classes associated with Dall sheep occurrence will be mapped for the CYR study area and used as a proxy for potential Dall sheep distribution. For caribou, seasonal distributions will be derived from existing range maps, refined using radio collar data when available, and reviewed by regional experts.

Limitations

As described above, the greatest limitation with using the AKGAP distribution models is the statewide scale at which the models were developed, and whether or not the mapped products are appropriate at the scale of the CYR REA study area. To ensure that they are suitable for the REA, we will assess the accuracy of the models using independent data (as described above) and also solicit expert review of the modeled outputs.

Aquatic Fine-Filter CEs

Seven species were selected as Aquatic Fine-Filter CEs for the Central Yukon REA. An effort was made to select species representative of different ecological niches. For example, northern pike broadly represent resident, long-lived species with the Central Yukon REA.

1. Chinook salmon (*Oncorhynchus tshawytscha*)
2. Chum salmon (*Oncorhynchus keta*)
3. Northern pike (*Esox lucius*)
4. Sheefish / inconnu (*Stenodus leucichthys*)
5. Humpback whitefish (*Coregonus pidschian*)
6. Dolly Varden (*Salvelinus malma*)

Datasets

Table 13 lists the datasets used the aquatic species analysis.

Table 13. Summary of datasets for the Aquatic Fine-Filter CEs.

Dataset Name	Data Source	Status
Anadromous Waters Catalog (AWC)	Alaska Department of Fish & Game	Obtained
Alaska Freshwater Fish Inventory (AFFI)	Alaska Department of Fish & Game	Obtained

Distribution Maps Methods

For each species, a distribution map will be created. The Alaska Department of Fish and Game (ADF&G) maintains the Anadromous Waters Catalog (AWC), which contains the spatial distribution of anadromous fish across the state, and the Alaska Freshwater Fish Inventory (AFFI), which contains the spatial distribution of freshwater fish. The AWC and AFFI will be used to represent the distribution of all fine-filter CEs. There were not enough distribution data for humpback whitefish (7 presence points within the CYR REA study area) and northern pike (22 presence points within the CYR REA study area), thus we have identified these two species as **data gaps** and will not be producing any spatial products for these CEs.

Limitations

No complete spatial distribution data for fish species currently exists and no absence data exists (that we are aware of, or that is available in digital format), limiting habitat distribution modeling efforts. Additionally, outside of commercial and subsistence fish species, almost no information on population sizes for other fish species exists. Information on the extent of anadromy or amphidromy is limited and very little is known about overwintering habitats for most species.

Limited information exists for specific threshold effects of attributes and indicators for Fine-Filter aquatic CEs. For example, there are few climate change predictions specific to each aquatic Fine-Filter CE, such as changes in winter precipitation and direct affects to species. Furthermore, water temperature data for aquatic habitats is lacking for the Central Yukon REA study area, thus air temperature is used as a proxy for interpreting changes in water temperature and the potential effects on CEs.

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Chapter 3: Integrated Products

Integration of core REA products allows for a synthetic assessment of the ecoregion that can provide additional insight into how the ecoregion is functioning currently, and how that might change in the future. For the integrated products (Figure 9) we look at several indicators that provide insight into the ecological integrity of the ecoregions (LCM, Landscape Intactness, and CE Status), and identify those areas that are likely to change the most (Cumulative Impacts). Each of these are described in detail below.

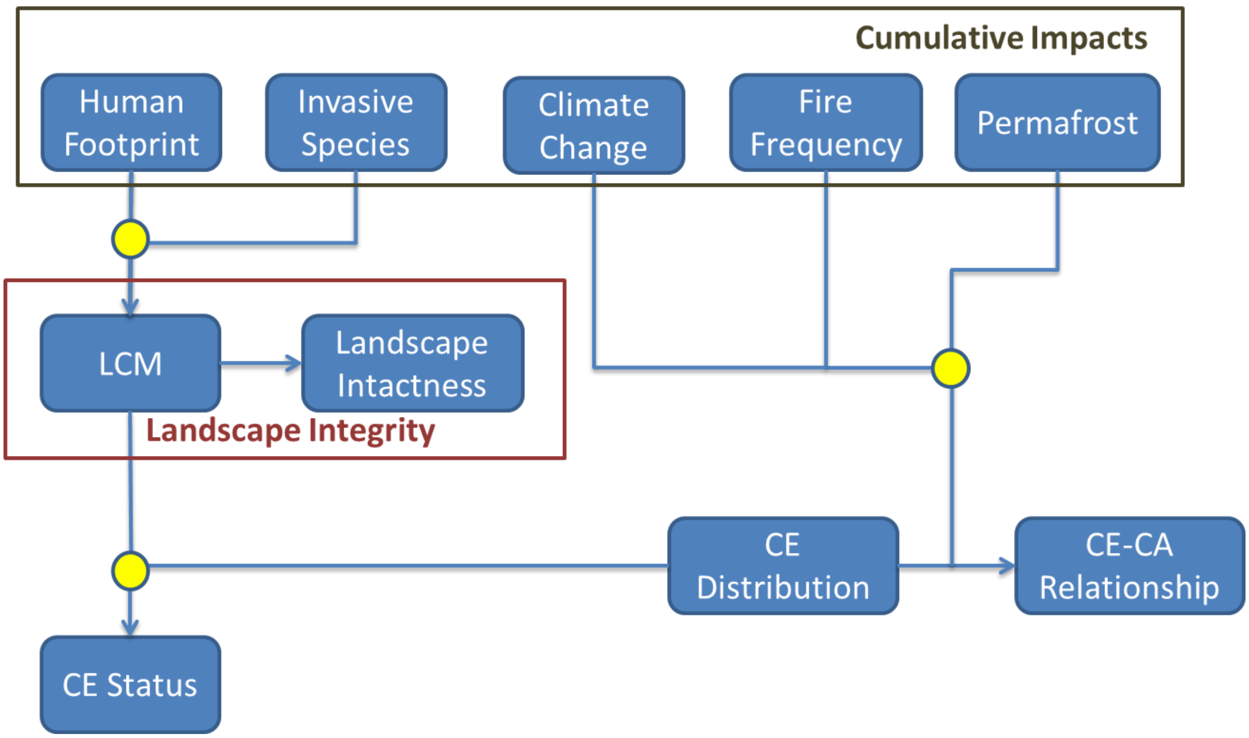

Figure 9. Diagram of various integrated products that will be developed to explore the integrity of the Central Yukon study area.

Landscape Integrity

Landscape integrity provides a quantifiable and readily assessable measure of naturalness, which can be used then to assess the current and potential future status of ecological resources. Landscape integrity can be easily calculated using existing datasets, yet is robust enough to be used in current and future scenario geospatial models. For this REA, landscape integrity will be modeled with parameters that are amenable to measurement, monitoring, scoring, and adaptive management. Future data will therefore have the potential to inform the landscape integrity model, producing updated results that will enable land managers to visualize the current and future status of the landscape. We propose modeling landscape integrity first by assessing the landscape condition (using the Landscape Condition Model developed by NatureServe, modified for use and application in Alaska) then assessing the continuity of the highest condition landscapes by quantifying Landscape Intactness.

Landscape Condition Model

The Landscape Condition Model (LCM) is a simple yet robust way to measure the impact of the human footprint on a landscape (Comer and Hak 2012). The LCM categorizes human modifications into different levels of impact (site impact score), based on the current state of knowledge about the impacts of specific human land uses (Table 14) collected from thousands of papers spanning many types of habitats and contexts. Permanent human modification is weighted the highest, while temporary use (such as snow machine trails), receive less weight. Intensive land uses, such as mining, are also weighted higher than less intensive land uses, such as cultivated lands. In addition to describing the relative impact of each land use, the LCM also identifies a distance at which the impact is no longer exhibited on the landscape (decay distance), again based on extensive meta-analysis of the impacts on many species/habitats/contexts. For the purpose on this assessment, we assume a linear distance decay function (gradual decrease in impact as you move further from the activity until you reach the maximum distance at which the impact is negligible).

Table 14. List of human modification variables used in the Landscape Condition Model (LCM) from Comer and Hak (2012), but modified based on availability of datasets and presence of specific threats. Decay scores with an * are modified from original LCM literature for conditions in Alaska, based on research by Strittholt et al (2006).

Theme	Data Source	Site Impact Score	Est. Relative Stress	Decay Distance (m)
Transportation				
Highways	AK DNR/TIGER	0.05	Very High	5000*
Secondary Roads	AK DNR/TIGER	0.2	High	2500*
Local and connecting roads	AK DNR/TIGER	0.5	Medium	500*
Historic 4x4 trails	AK DNR	0.5	Medium	250
Trails (snow machine, sled dog)	AK DNR	0.7	Low	500*
Urban and Industrial Development				
High Density Development	NLCD 2013	0.05	Very High	2000
Medium Density Development	NLCD 2013	0.3	Medium	1000
Low Density Development	NLCD 2013	0.6	Medium	1000
Powerline/Transmission lines	USGS/AK DNR	0.5	Medium	500
Oil /gas Wells	BLM/AK DNR	0.5	Medium	500
Historic Mines	ARDF/BLM/State	0.5	Medium	500
Current Mines	ARDF/BLM/State	0.05	Very High	1500*
Managed and Modified Land Cover				
Cultivated Lands	NLCD 2013	0.3	High	200
Introduced Vegetation	NLCD 2013/AKEPIC	0.5	Medium	200

By applying these different impact and decay scores to the various land uses, a surface raster representing the relative condition of the landscape, scored 0 (for very low condition) to 1 (very high condition) is created. Where two or more land uses and their decay scores overlap, we propose using the minimum (thus the highest impact) score, assuming that high-impact features are not additive. The LCM will then be summarized per 5th-level HUC (Figure 10) to facilitate use in the Cumulative Impacts model (see description below).

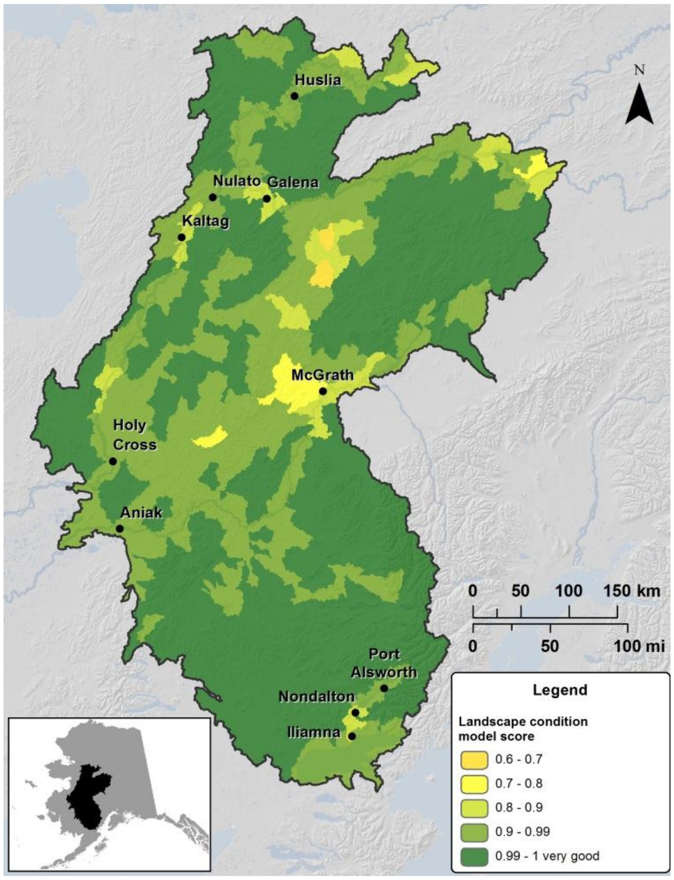

Figure 10. Near Term (2025) Landscape Condition Model summarized at 5th-level HUCs for the Yukon, Kuskokwim, Lime Hills REA. Low scores indicate poor condition, while larger scores (approaching 1) represent good condition landscapes.

Landscape Intactness

Merely considering the condition without considering the landscape context may misrepresent the actual impact of different human activities on the overall landscape integrity. Most importantly, landscape condition should not be assessed at a particular location without some explicit consideration of the surrounding environment (Scott et al. 2004). To address this, we suggest identifying landscape intactness by extracting contiguous areas that have a LCM score in the top 20% for the ecoregion. We propose using three size thresholds to correspond to other efforts that have taken place in Alaska to map unfragmented habitats (Table 15). First, we propose looking at blocks that are greater than or equal to 50,000 acres to coincide with the Global Forest Watch program from the World Resources Institute and their Intact Forest Landscapes (Strittholt et al. 2006). Second, we propose looking at blocks that are less 50,000 acres but greater than or equal to 10,000 acres to correspond to previous wilderness area designations studies (Geck 2007). Third, we will identify all the blocks that are less than 10,000 acres as potentially vulnerable to disturbances.

Table 15. Proposed categories for assessing landscape intactness.

Size	Designation
≥ 50,000 acres	Highest Landscape Integrity
< 50,000 acres, ≥ 10,000 acres	High Landscape Integrity
< 10,000 acres	Vulnerable to change

Conservation Element Status

While distribution models of CEs helps understand the relative extent of key ecological resources, it does not provide insight into the integrity of those resources. To facilitate better understanding of the integrity of the ecosystems present in these ecoregions, we propose to assess the status of CEs by overlaying the distribution model (described in Chapter 2) with the Landscape Condition Model. When additional information is available, the LCM will be modified to reflect species-specific responses to human disturbances (for example, golden eagles are disturbed when human traffic occurs within 2 km of nesting sites). When the status of each CE is summed, managers will have an indication of overall ecological integrity.

Cumulative Impacts (CI)

The final integrated product we proposed developing is called Cumulative Impacts (CI). The measurement of cumulative impacts has become increasingly emphasized both in the academic literature (Walker 1987, Theobald et al. 1997, Nellemann and Cameron 1998, Belisle and St. Clair 2001) as well as regulatory requirements (NEPA, WGA, etc.). Essentially, the CI presents a rolled-up dataset of all potential threats to the landscape to identify the locations within the REA that are likely to experience the most amount of change. The inverse of this dataset could be seen as a landscape vulnerability index (LVI) that could be used to assist in future resource planning efforts. The concept behind the CI is that CAs will not change in isolation of each other. Future environments will be shaped by all the CAs interacting and changing together to create a new landscape. To identify where those new landscapes are most likely to occur, we propose combining all CAs into a single measure summarized at the 5th-level HUC.

The CI analysis includes what we consider the primary CAs likely to have the largest and most direct impact on the ecoregion. However, in order to “sum” the impacts we had to define meaningful changes in the CAs, realizing that the CI analysis is not targeted on any one CE. We define meaningful change for each CA independently:

- Mean January Temperature
  - Meaningful change in January temperature will be defined by examining the variance between the five climate models (described in Chapter 1), and assigning a value of 1 to regions that demonstrate significant change.
- Mean July Temperature
  - Meaningful change in July temperature will be defined by examining the variance between the five climate models (described in Chapter 1), and assigning a value of 1 to regions that demonstrate significant change.

- Annual Precipitation
    - Meaningful change in annual precipitation will be defined by examining the variance between the five climate models (described in Chapter 1), and assigning a value of 1 to regions that demonstrate significant change.
- Change in Permafrost
    - Meaningful change in permafrost will be calculated based on the change in mean annual ground temperature (see Chapter 1). Specifically, HUCs where more than 10 cells (20 km^2) where forecasted to increase above -1°C (i.e., the change from continuous to discontinuous permafrost) will be given an impact score of 1.
- Change in Area Burned per Year
    - Change in in fire characteristics will be assessed by comparing current to future area burned per year in each fire subregion (see Chapter 1). A 10% increase in area burned per year would be considered meaningful and given an impact score of 1.
- Landscape Condition
    - Any changes in landscape condition, at the 5^{th}-level HUC, will be considered meaningful for the cumulative impact assessment and assigned an impact score of 1.
- Invasive Species Vulnerability
    - Any change in invasive species vulnerability will be considered meaningful for the cumulative impact assessment and assigned an impact score of 1.

Limitations

While considered a robust way to measure naturalness, there are some key assumptions made in the conceptualization of landscape integrity. While obvious at a local scale, human footprints are not always well mapped or captured in a geospatial framework. This is especially true for historical human use (i.e. native use, or even modern historical use prior to the establishment of environmental monitoring programs). Thus, our landscape integrity model assumes that the current and historical human footprint is accurately modeled for the region. This is especially relevant as one of the key outputs from an REA is a better understanding of the indirect impacts of human activity on ecosystems.

Furthermore, given the cross-disciplinary nature of the core REA analyses, there exists a high potential for error. Modeled outputs will be placed into other models, each with different assumptions, potentially propagating errors throughout. Using GIS as a common platform can assist in identifying errors early in the modeling process, and (by creating intermediate data products) provides a transparent process in which critical review of our assumptions can be made. Thus, while many of these models were never designed to interact, we feel confident that all our modeling efforts represent the best available knowledge about the system and the potential impacts of the “known and unknown unknowns”.

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Chapter 4. Management Questions

In this chapter, we provide detail on each of the twenty selected Management Questions (MQs) including background information, desired products, applicable datasets, modeling methods and expected outputs, and challenges or limitations. Our intent is to provide transparency in the process, and to clarify how we hope to address each questions with respect to interpretation, context, scale, and detail.

Most of the MQs require datasets that are also required for the core analyses of CEs and CAs, therefore these data are not presented in the MQ discussion. However, since MQs are inherently additional products separate of the core analysis, additional data is often required to fully address the MQ. In these situations, additional data are presented in a table with the methods. These data sources are also listed in Appendix A. All original MQs from the BLM had overarching questions of “How reliable are these predictions? Are there other data/models which provide information that is different than the output presented?”. These questions are specifically addressed as a standard component to all of the Process Models.

MQ A1: How is climate change likely to alter the fire regime in the dominant vegetation classes and riparian zones?

Description

For this management question we will model projected fire frequency, overlay outputs with spatial maps of dominant vegetation classes and riparian zones, and spatially analyze the results.

Methods

We will project fire frequencies using the ALFRESCO (Alaska Frame-based EcoSystem Code) model. ALFRESCO operates on an annual time step, in a landscape composed of 1 × 1 km pixels. The model simulates a range of ecosystem types, including graminoid tundra, shrub tundra, wetland tundra, black spruce forest, white spruce forest, deciduous forest, and grassland-steppe. ALFRESCO does not model fire behavior but rather models the empirical relationship between growing-season (May–September) climate (e.g., average temperature and total precipitation) and total annual area burned (i.e., the footprint of fire on the landscape). ALFRESCO also models the changes in vegetation flammability that occur during succession through a flammability coefficient that changes with vegetation type and stand age (i.e., succession).

The model focuses on system interactions and feedbacks. The fire regime is simulated stochastically and is driven by climate, vegetation type, and time since last fire. ALFRESCO employs a cellular automaton approach, where simulated fire may spread to any of the eight surrounding pixels. “Ignition” of a pixel is determined as a function of the flammability value of that pixel and a randomly generated number. The flammability of each pixel is a function of vegetation type and age, meaning that ignitions will be concentrated in pixels with the highest fuel loads and the driest climate conditions. Fire spread depends on the flammability (i.e., fuel loading and moisture) of the receptor pixel. Some pixels, e.g., non-vegetated areas and large water bodies, do not burn and thus serve as fire breaks. Suppression activities are not simulated.

ALFRESCO has been calibrated using available literature regarding burn rates and stand compositions. In addition, the model is calibrated through use of a “spinup” period of 1000 years of simulated fire history, in order to match outputs as closely as possible to historical fire patterns. The model parameters derived during this spinup period are then used to create future projections.

Given that ALFRESCO is a stochastic model, each model run represents one possible set of fire occurrences (across space and time), given a particular modeled set of climate input variables. ALFRESCO is carefully calibrated, using historical fire and climate data. However, variability between runs is extremely high, representing the inherently high variability of fire behavior. Thus, all analyses for this REA will use either averages across many model runs or representational “best replicates” selected statistically from among many runs (Figure 11). For this MQ, fire frequency outputs (probability of fire, by decade) will be overlain with spatial representations of dominant vegetation classes and riparian zones (to be determined as part of the core analyses). This spatial overlay will most likely be by ecological sub-region, since finer resolution outputs of stochastic model results tend to be misleading. In some cases, looking at time periods outside of those used in other sections of the REA analysis may help shed light on long-term changes. ALFRESCO runs include data from 1900 to 2100.

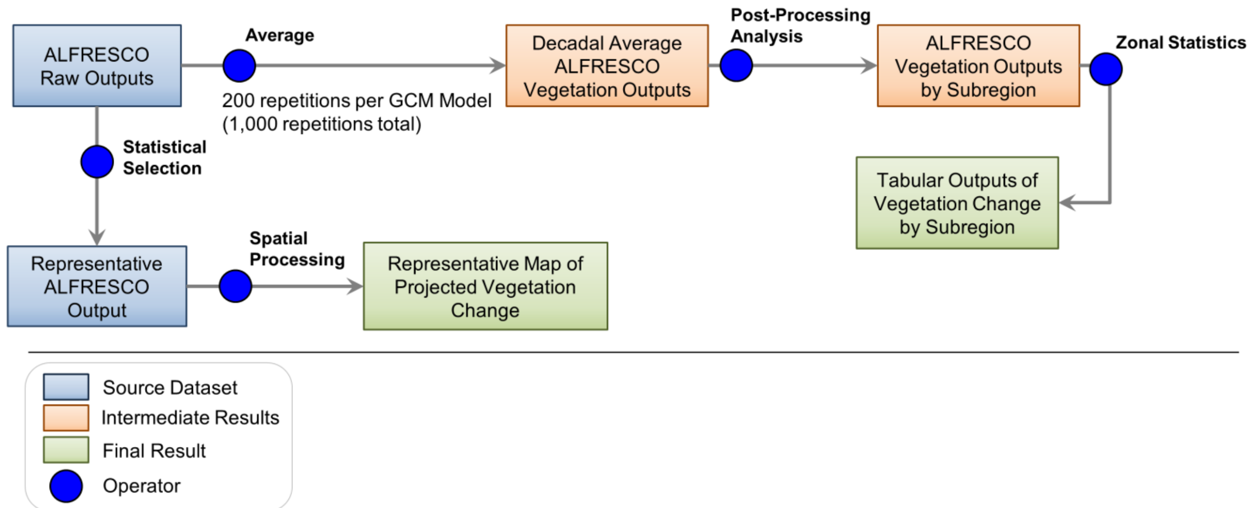

Figure 11. Process model for analysis of the change in fire regime in dominant vegetation classes in response to climate change (MQ A1).

Limitations

How reliable are these predictions?

Uncertainty is inherent in all climate projections and associated fire projections; much of this uncertainty is addressed by using averages across multiple models and across decades, but all projections must still be understood in the context of SNAP's methodology and ALFRESCO's parameters. ALFRESCO output data, although spatial, are also stochastic, and must always be viewed as such. The model can predict the general likelihood of fire and/or vegetation shift for particular time periods and locations, but never the specific sites or times of fire events. Outputs, although relatively fine-scale, do not always match the scale of phenomena that affect CEs. Moreover, available data do not always match, in scale or detail, the attributes and indicators most closely linked to particular fine or coarse CEs. Even when linkages between CEs and fire are relatively clear, in many cases, the literature does not provide precise information regarding threshold values.

Are there other data/models which provide information that is different than the output presented?

No other fire models currently exist that link fire, vegetation, and climate in this region. However, a linked model using the same data and sub-models (ALFRESCO, SNAP climate data, and GIPL permafrost data) is currently being created as part of the Integrated Ecosystem Modeling (IEM). This is a SNAP project; as such, if pertinent outputs are available within the time constraints of this project, they will be integrated into the REA.

MQ B1: How is climate change likely to alter permafrost distribution, active layer depth, precipitation regime, and evapotranspiration in this region?

Description

We will address this MQ by analyzing current and future outputs from several different climate-linked models, including SNAP precipitation and evapotranspiration models and GIPL/SNAP permafrost models.

Methods

As for the core analysis, to answer this MQ we will rely on SNAP climate datasets that have been downscaled to 771 meter resolution. A composite (average) of the five GCMs selected and downscaled by SNAP will be used in order to minimize uncertainty due to model bias, with outputs from the A2 scenario, representing a realistic view of future emissions. Decadal averages will be used, as opposed to data for single years, in order to reduce error due to the stochastic nature of GCM outputs, which mimic the true inter-annual variability of climate.

Although data are available at 771m resolution, spatial analysis may include assessment at borader spatial scales such as ecological sub-regions, in order to provide a clearer view of which parts of the REA may experience greatest and least change for each climate variable mentioned in this MQ. While separate assessment of these variables is part of the core analysis, this question demands that selected variables be assessed together. This may be more effectively explored and discussed at a broader scale. In this context, “spatial analysis” may include averaging across sub-regions, finding minimum or maximum values within sub-regions, or assessing variability (e.g. standard deviations) within sub-regions.

SNAP precipitation data are at a monthly resolution, but may be combined into seasonal or annual averages for this MQ. In addition, SNAP has used temperature data to create spatial estimates of potential evapotranspiration (PET), although literature review may shed more light on this question.

Permafrost data will come from the GIPL permafrost model, which calculates permafrost extent, mean annual ground temperature, mean annual ground surface temperature, active layer thickness, snow warming effect, and thermal onset from data inputs relating to the geologic and soil properties, effects of ground insulating snow and vegetation layers, and predicted changes in air temperature and annual precipitation. The primary outputs relevant to this MQ are the mean annual ground temperature (MAGT) at one meter depth, and the active layer thickness (ALT), which represents two different outputs: the depth of seasonal (summer) thaw, for areas with permafrost at one meter depth, and the maximum depth of seasonal (winter) freezing, for areas that are free of permafrost. The model is ground-truthed and validated using cores from around the state (GIPL 2013). The methods for this MQ are diagrammed in Figure 12 below.

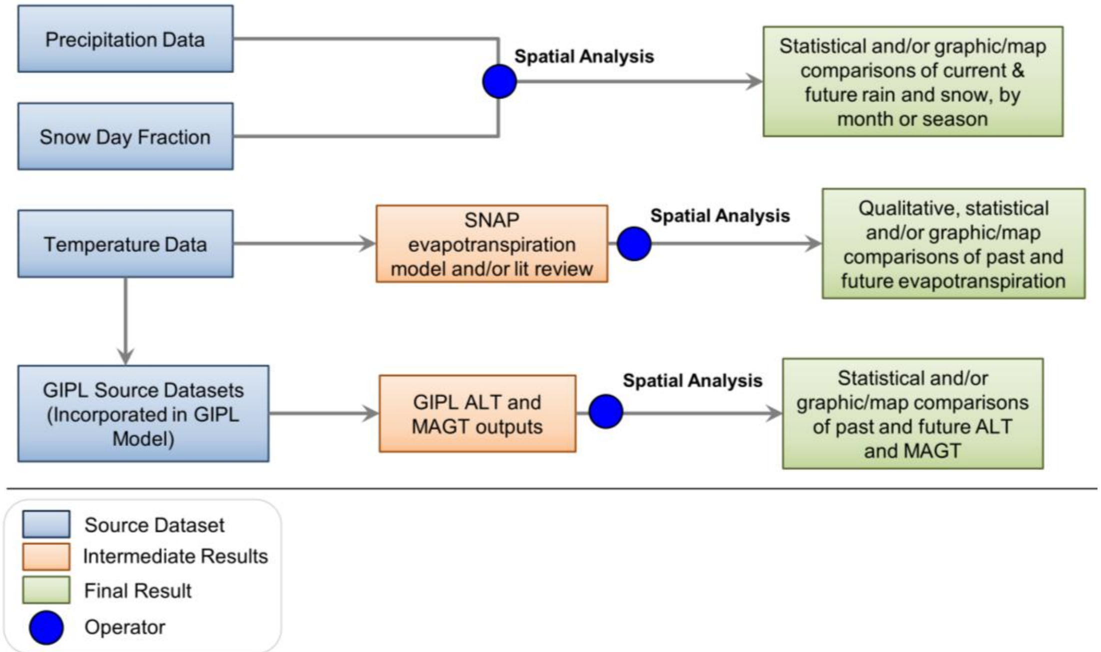

Figure 12. Process model for analysis of the effects of climate change on permafrost distribution, active layer depth, precipitation regime, and evapotranspiration (MQ B1).

Limitations

How reliable are these predictions?

Uncertainty is inherent in all climate projections; much of this uncertainty is addressed by using averages across multiple models and across decades, but all projections must still be understood in the context of SNAP's methodology. Climate data, while relatively fine-scale, do not always match the scale of phenomena that affect CEs. Moreover, available data do not always match, in scale or detail, the climate-related attributes and indicators most closely linked to particular fine or coarse CEs. Even when linkages between CEs and climate variables are relatively clear, in many cases, the literature does not provide precise information regarding threshold values. The GIPL permafrost model provides a general and coarse approximation of permafrost conditions across the landscape. Fine-scale changes in permafrost micro-conditions at a scale of meters rather than kilometers cannot be accurately predicted by the GIPL model. For example, the GIPL model cannot predict the formation of specific thermokarst features or the drainage of specific lakes from permafrost thaw. However, the predicted changes in permafrost at the landscape level indicate where such phenomena will be most likely.

Are there other data/models which provide information that is different than the output presented?

No other models are available that provide similar data at the resolution offered by the models described above, although SNAP does offer data from other emission scenarios (A1B and B1). GIPL has been working with SNAP partners and others on an Integrated Ecosystem Management project (IEM). Although not yet complete, the project has already offered some completed products, including spatial projections of thermokarst risk. These outputs may be used to augment analysis for this MQ. As noted, literature review may shed more light on changes in evapotranspiration than model outputs, given the limitations of this model.

MQ B2: What are the expected associated changes to dominant vegetation communities and CE habitat in relation to altered permafrost distribution, active layer depth, precipitation regime, and evapotranspiration?

Description

This question asks us to link projections of permafrost change and precipitation regime to ecosystem components, with the final product being statistical or spatial analysis of effects on CE habitat.

Methods

SNAP climate and GIPL results from MQ B1 will be linked to CE habitat through a series of spatial intersections exploring current and future changes to vegetation communities (Figure 13). Results will be displayed in tabular, graphical, or spatial formats, and the ecological significance will be interpreted through a literature review. This MQ will be answered in conjunction with CE analysis, thus linking CA and CE conditions and projected change.

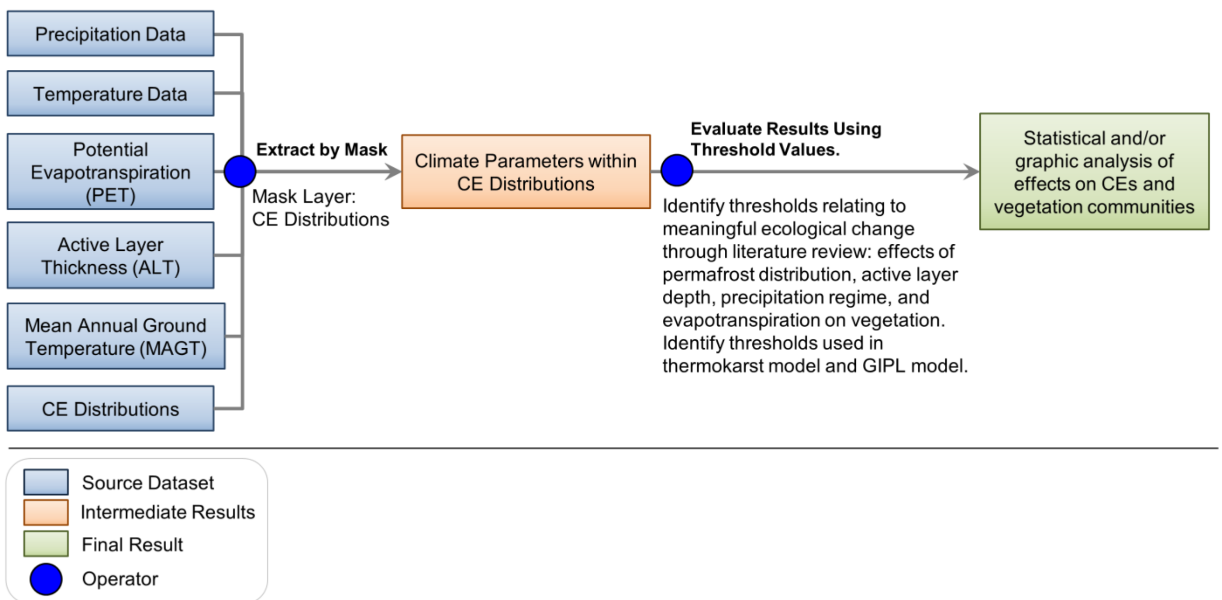

Figure 13. Process model for evaluating changes to vegetation in relation to changes in permafrost distribution, active layer, precipitation, and evapotranspiration (MQ B2).

Limitations

See MQ B1 for limitations of the SNAP models. The landcover maps used to develop the CE distributions have inherent limitations. The reported overall accuracy for the interior boreal portion of the NLCD map is 63.9% (Selkowitz and Stehman 2011), and the mosaicked map produced by AKNHP (Boggs et al. 2014) is compiled from maps of varying accuracies. For example, the maps produced by Ducks Unlimited generally report accuracies ranging from 65-80%, however, many of these are based on old satellite imagery and are now out-of-date. Several of the maps produced by the National Park Service do not have reported accuracies.

How reliable are these predictions?

See MQ B1

Are there other data/models which provide information that is different than the output presented?
See MQ B1

MQ C1: How will changes in precipitation, evapotranspiration, and active layer depth alter surface water availability and therefore ecosystem function (dominant vegetation classes)?

Description

For this MQ, we will overlay outputs from SNAP precipitation and evapotranspiration models and SNAP/GIPL permafrost models with maps of vegetation from the core analysis (Coarse-Filter CEs) and maps of current surface water.

Methods

As for the core analysis, to answer this MQ we will rely on SNAP climate datasets that have been downscaled to 771 meter resolution. A composite (average) of the five GCMs selected and downscaled by SNAP will be used in order to minimize uncertainty due to model bias, with outputs from the A2 scenario, representing a realistic view of future emissions. Decadal averages will be used, as opposed to data for single years, in order to reduce error due to the stochastic nature of GCM outputs, which mimic the true inter-annual variability of climate.

SNAP precipitation data are at monthly resolution, but may be combined into seasonal or annual averages for this MQ. In addition, SNAP has used temperature data to create spatial estimates of potential evapotranspiration (PET), although literature review may shed more light on this question.

Surface water will be mapped along with coarse filter CEs, and as such will rely on selection methods discussed elsewhere. However, the relationship between surface water and projected changes in the above variables will primarily be determined via literature review, published data, and expert opinion. Determining how to effectively combine these variables may prove to be the bulk of the work in answering this MQ. It is likely that such changes will be more viably discussed at a sub-regional level, rather than at a pixel-by-pixel level. Spatial analysis (e.g. using mean, max, or min values across selected sub-regions or vegetative zones) wil be necessary to present and discuss these changes.

Permafrost data will come from the GIPL permafrost model, which calculates permafrost extent, mean annual ground temperature, mean annual ground surface temperature, active layer thickness, snow warming effect, and thermal onset from data inputs relating to the geologic and soil properties, effects of ground insulating snow and vegetation layers, and predicted changes in air temperature and annual precipitation. The output relevant to this MQ is the active layer thickness (ALT), which represents two different outputs: the depth of seasonal (summer) thaw, for areas with permafrost at one meter depth, and the maximum depth of seasonal (winter) freezing, for areas that are free of permafrost. The model is ground-truthed and validated using cores from around the state (Sazonova and Romanovsky 2003).

This MQ analysis will rely on vegetation classes defined in the core analysis. Methods for selecting these classes are discussed elsewhere. The methods for this MQ are diagrammed in Figure 14 below.

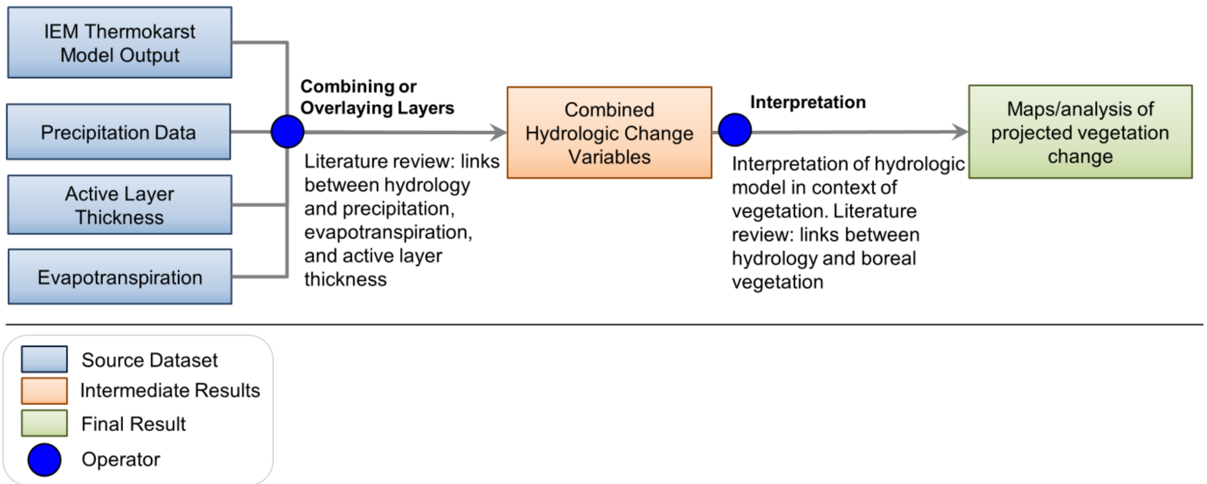

Figure 14. Process model for analysis of the effects of changes in precipitation, evapotranspiration, and active layer thickness on surface water availability and vegetation (MQ C1).

Limitations

How reliable are these predictions?

Uncertainty is inherent in all climate projections; much of this uncertainty is addressed by using averages across multiple models and across decades, but all projections must still be understood in the context of SNAP's methodology. Climate data, while relatively fine-scale, do not always match the scale of phenomena that affect CEs. Moreover, available data do not always match, in scale or detail, the climate-related attributes and indicators most closely linked to particular fine or coarse CEs. Even when linkages between CEs and climate variables are relatively clear, in many cases, the literature does not provide precise information regarding threshold values. The GIPL permafrost model provides a general and coarse approximation of permafrost conditions across the landscape. Fine-scale changes in permafrost micro-conditions at a scale of meters rather than kilometers cannot be accurately predicted by the GIPL model. For example, the GIPL model cannot predict the formation of specific thermokarst features or the drainage of specific lakes from permafrost thaw. However, the predicted changes in permafrost at the landscape level indicate where such phenomena will be most likely.

Are there other data/models which provide information that is different than the output presented?

Many choices of vegetation mapping are available, but this MQ analysis will rely, for the sake of consistency, on vegetation classes defined in the core analysis. No other models are available that provide similar data at the resolution offered by the models described above, although SNAP does offer data from other emission scenarios (A1B and B1). GIPL has been working with SNAP partners and others on an Integrated Ecosystem Management project (IEM). Although not yet complete, the project has already offered some completed products, including spatial projections of thermokarst risk. These outputs may be used to augment analysis for this MQ. As noted, literature review may shed more light on changes in evapotranspiration than model outputs, given the limitations of this model.

MQ E1: How is climate change affecting the timing of snow melt and snow onset, spring breakup and green-up, and growing season length?

Description

For this management question we will use SNAP climate data and derived seasonality datasets to model changes in seasonal timing.

Methods

SNAP has created current and future datasets estimating the date at which temperatures cross the freezing point in the spring and fall (termed "thaw date" and "freeze date" – although a direct correlation with ice on water bodies or in soils would not be expected). In addition, SNAP has used temperature data to create monthly estimated current and future snow fraction datasets (percentage of precipitation expected to fall as snow). As with other SNAP data used in the core analysis, these are downscaled to 771 m using PRISM, and are based on decadal averages of 5-GCM averages, for the A2 emissions scenario.

These datasets will be coupled with information from the literature on lag times between the various thresholds described in the question in order to shed light on how each of these indicators of seasonality may change over time. The methods for this MQ are diagrammed in Figure 15 below.

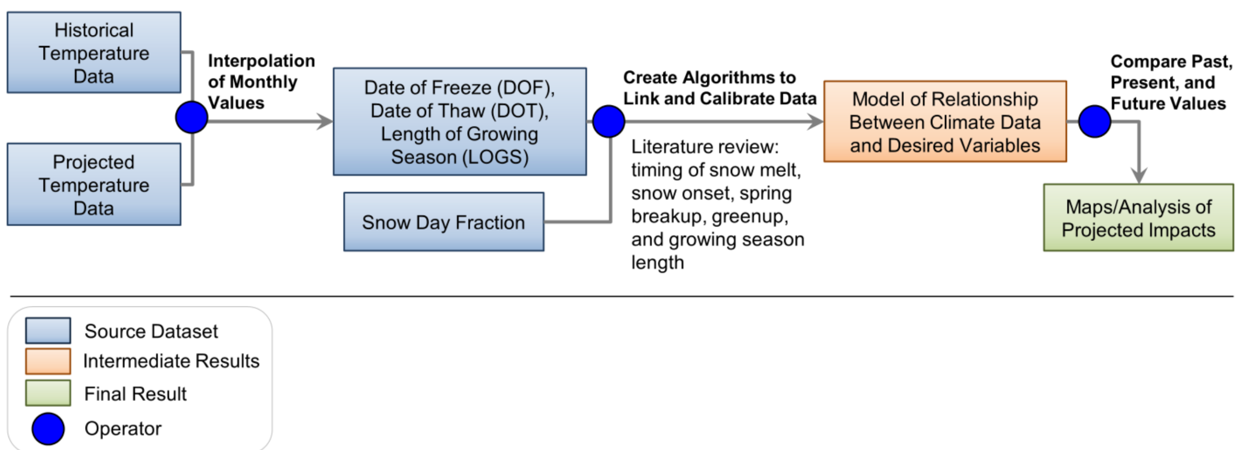

Figure 15. Process model for analysis of climate change effects on timing of snow melt and snow onset, spring break-up and green-up, and growing season length (MQ E1).

Limitations

How reliable are these predictions?

Uncertainty is inherent in all climate projections; much of this uncertainty is addressed by using averages across multiple models and across decades, but all projections must still be understood in the context of SNAP's methodology. Climate data, while relatively fine-scale, do not always match the scale of phenomena that affect CEs. Even when linkages between CEs and climate variables are relatively clear, in many cases, the literature does not provide precise information regarding threshold values. In the case of the variables addressed in this MQ, it is likely that the relationship between climate and each variable is imperfectly understood.

Are there other data/models which provide information that is different than the output presented?

No other models are available that provide similar data at the resolution offered by the models described above, although SNAP does offer data from other emission scenarios (A1B and B1). As noted, literature review may be needed to address this question.

MQ F3: How are major vegetation successional pathways likely to change in response to climate change, with special emphasis on increased shrub cover and treeline changes?

Description

Warming temperatures and changes in fire frequency will alter vegetation succession and change the distribution of certain vegetation types on the landscape. Changes linked to fire, temperature and precipitation will be modeled and explored.

Methods

We will use SNAP ALFRESCO results from MQ A1 to quantify change in CE distribution by sub-region. If spatial data are made available by SNAP, we will use the spatial representation of the "best replicates" (see MQ A1) for shrub expansion and treeline expansion to evaluate where these changes are most likely to occur (Figure 16). Through a literature review, we will provide descriptions of successional pathways and potential deviations resulting from climate change.

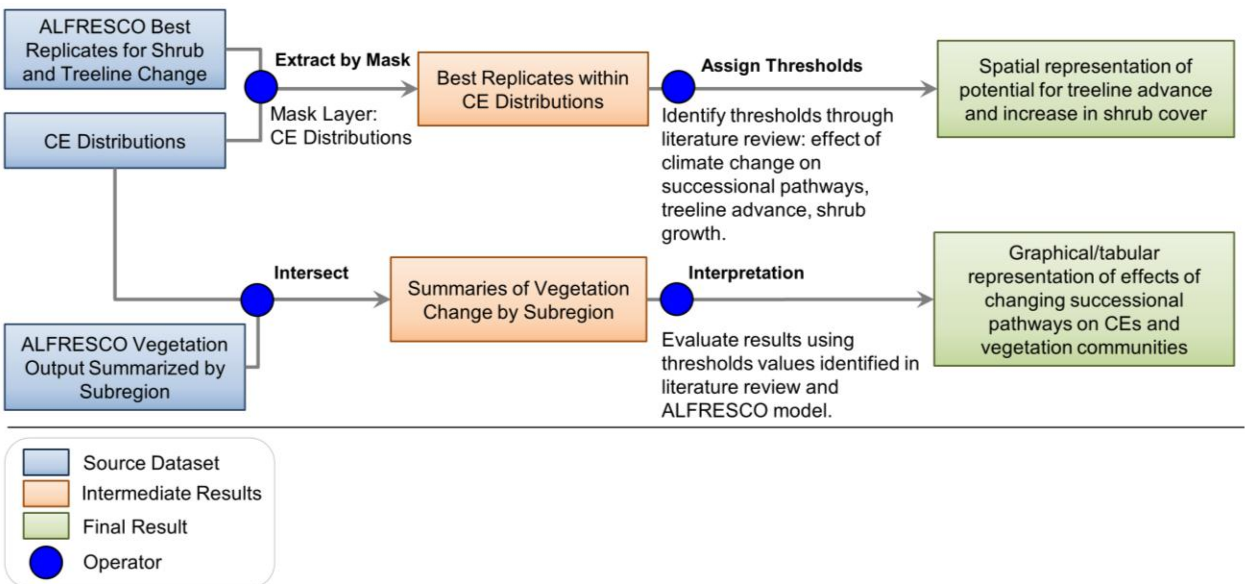

Figure 16. Process model for analysis of vegetation change in response to climate change (MQ F3).

Limitations

See ALFRESCO limitations described in MQ A1. The landcover maps used to develop the CE distributions have inherent limitations. The reported overall accuracy for the interior boreal portion of the NLCD map is 63.9% (Selkowitz and Stehman 2011), and the mosaicked map produced by AKNHP (Boggs et al. 2014) is compiled from maps of varying accuracies. For example, the maps produced by Ducks Unlimited generally report accuracies ranging from 65-80%, however, many of these are based on old satellite imagery and are now out-of-date. Several of the maps produced by the National Park Service do not have reported accuracies.

How reliable are these predictions?

See reliability limitations described in MQ A1.

Are there other data/models which provide information that is different than the output presented?

See MQ A1 for description of other models.

MQ Q1: Which subsistence species (aquatic and terrestrial) are being harvested by whom and where is harvest taking place?

Description

Subsistence species are harvested both for subsistence purposes and by commercial and sport hunters. However, quotas apply and hunting locations by type of hunt (subsistence vs. others) impacts the availability of species for other hunt types. Data on three variables in this question – species, harvester, and location – will be collected from available sources. All data will be presented spatially.

Methods

There is no commercial hunting in the CYR REA region. Thus, only two types of hunting exist – subsistence, and sport hunting. Subsistence hunting harvest data is collected by ADF&G through their annual surveys. This dataset provides the quantity of each species harvested by a sample of households in each community. In addition, these surveys also collect spatial data on subsistence use areas. Geographic location of a hunt is not reported. This data will be combined with the sport harvest data reported by the game management unit (GMU). This combination will provide data on all three variables for terrestrial species. There is some commercial fishing of certain species in the Yukon River, although it has been closed in large parts of the fishery for over several years. Weak salmon runs over the years also provide limited subsistence harvest opportunities. Sport harvest is also limited. Sport harvest is reported by fishery districts. Subsistence harvest is reported by community, collected through the ADF&G subsistence harvest surveys. All these will be combined and spatially reported (Figure 17).

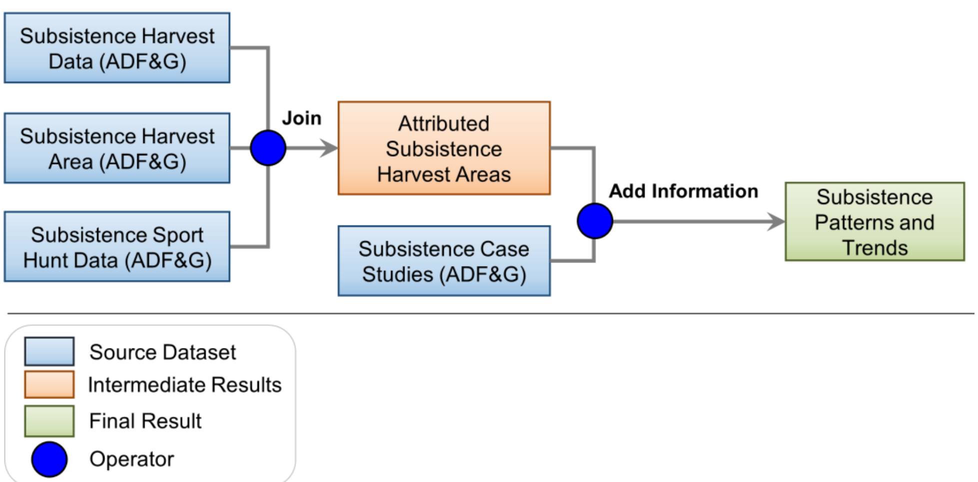

Figure 17. Process model for analysis of subsistence species harvest (MQ Q1).

Limitations

While hunting and fishing is reported by aggregate units, exact location data of either hunting or fishing for any species is limited or unavailable. In addition, the ADF&G surveys are not conducted every year in every community, and large gaps exist in the available data. Spatial data on subsistence use areas is available for one or two years for a limited number of communities. Given the large data gaps, this data is only as reliable as its coverage over time and across the geography. Data for different types of hunts are available at varying geographic scale. While the subsistence data derived from a household sample at a community level, the sport and commercial fishing and hunting is a 100% count.

How reliable are these predictions?
This question does not involve predictions.

Are there other data/models which provide information that is different than the output presented?
There may be other hunting and fishing data that are not publicly available. These data are collected as part of the ADF&G survey efforts, and the regular sport and commercial fishing permitting and reporting process. In addition, many private companies commission studies to inform their activities. Such proprietary data is often available in aggregate or derived formats in print publications but not in its raw format.

MQ U1: Compare the footprint of all types of landscape and landscape disturbances (anthropogenic and natural changed) over the last 20 and 50 years?

Description
A comprehensive current human footprint will be developed from various sources and will include elements such as communities, transportation facilities, energy development, resource development infrastructure, military sites, and recreation. Identifying the status of such a human footprint 20 and 50 years ago will be a challenge to the extent digital information may be available. Historical information on many elements in the human footprint may be identified from a review of documents.

Methods
This question will be answered through a review of historic documents in human activity in the CYR region, and systematically identifying the timeline of development in the region (Figure 18). Each element in the human foot print will be identified if it was present 50 years ago, and 20 years ago. Thus, the foot print will be reconstructed at both these points in time. The changes will be identified spatially.

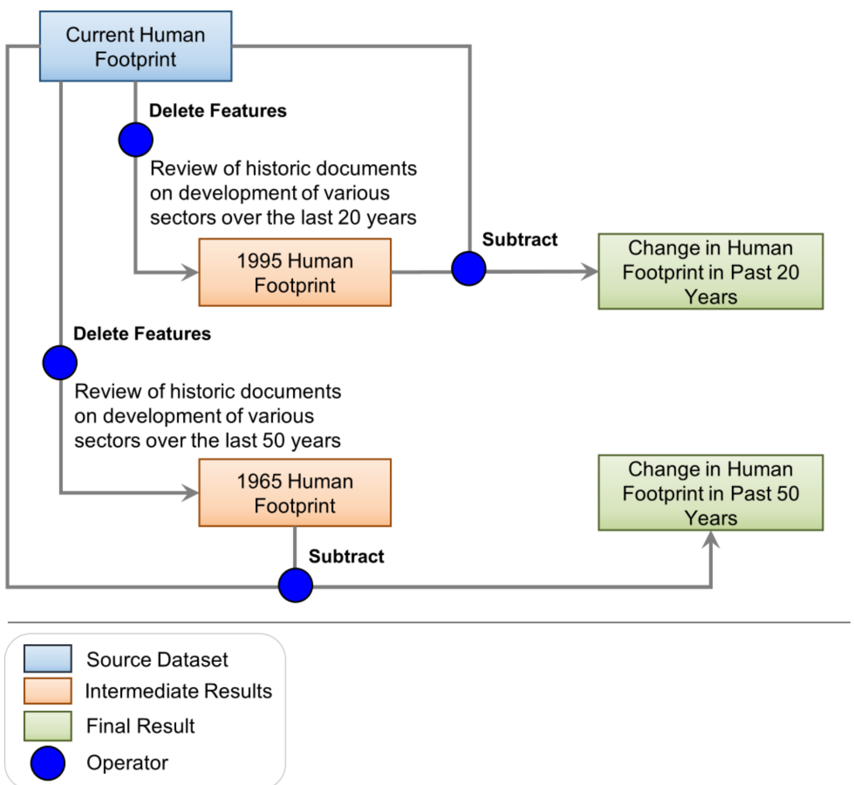

Figure 18. Process model for analysis of historic human footprint (MQ U1).

Limitations
We will be limited by the availability of historical information, and the amount of time available within the scope of this project to identify the historic development of the human foot print in the region.

How reliable are these predictions?
This question does not involve predictions.

Are there other data/models which provide information that is different than the output presented?
Finding historical information is a very involved task. It can take decades of research to unearth many important changes. Much historic information on changes in human foot print and natural landscapes may not have been recorded, or it may not be in digital format. Therefore, it is highly likely that much more information exists than what can be captured within this project. Similarly, this exercise in recording historic changes depends heavily on available digital information, and simple spatial techniques. No historical research methods are being used in examining the specific changes. All the available research methods in historical research can be incorporated in identifying and adding information to this model.

MQ U3: How and where is the anthropogenic footprint most likely to expand 20 and 50 years into the future?

Description

A comprehensive current human footprint will be developed from various sources and will include elements such as communities, transportation facilities, energy development, resource development infrastructure, military sites, and recreation. Identifying the status of such a human footprint 20 and 50 years from now is only possible to the extent information is available for future plans. Much of the development in Alaska, especially in the CYR region, depends so heavily on the oil and gas industry. Most development in the region in the last 50 years has been around Fairbanks and towards the oil fields in Prudhoe Bay. Most new development will likely follow the same pattern, guided by whatever new resource development activities may be planned. Plans for such activities depend on many things including the economic health of the state and markets.

Methods

This question will be answered through a review of policy and plan documents available through various permitting agencies and divisions of the state and federal government. Thresholds will be identified for determining the feasibility of future development. Projections of population and other social and economic indicators will inform our feasibility thresholds. The changes will be identified spatially (Figure 19).

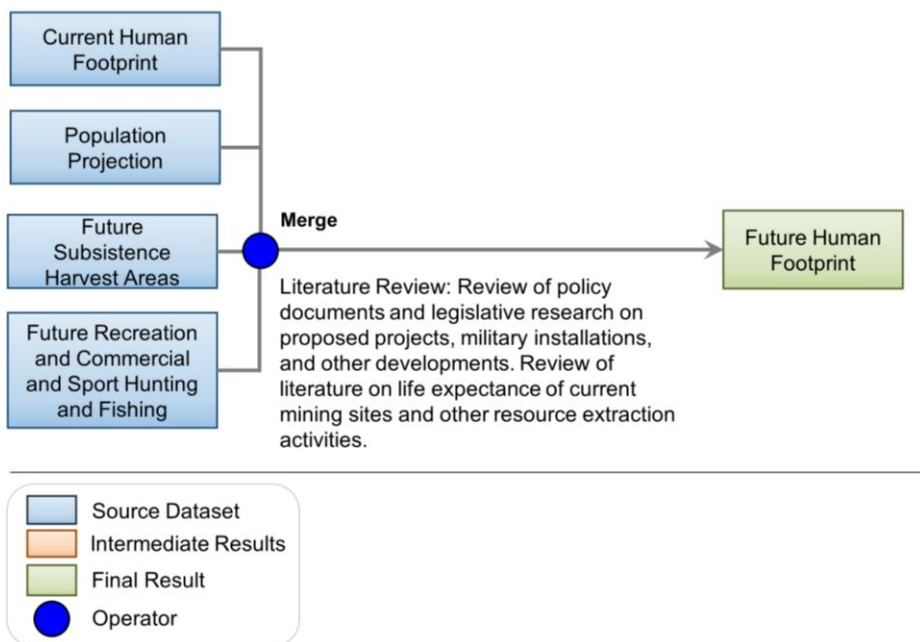

Figure 19. Process model for analysis of future anthropogenic footprint (MQ U3).

Limitations
We will be limited by the availability of policy documents.

How reliable are these predictions?
Predictions of future human footprint are based on projections of various demographic, social, and economic indicators, in addition to potential policy and legislative changes. While demographic, social, and economic trends can be partly reliable, that depends heavily on the components used to inform such projections. For example, demographic projections for CY region (by all the types of groupings of communities) could not consider important components such as birth rate, mortality rate, and migration rate. This information is either not available or accessible at a community level. Thus, these projections while informative are not very reliable. Similarly, projects of future human footprint based on potential policy or legislative changes are subject to abrupt shifts. These projects are based on current plans and expectations. Many factors can influence and change the course of development.

Are there other data/models which provide information that is different than the output presented?
Similar to the challenges in identifying change over the past decades, this projection may miss certain planned changes. However, any new information not included in this model can be added to it to produce a more comprehensive and accurate picture. This is a simple model of compiling all available information. A scenario planning exercise would be a more accurate projection.

MQ AH1: What rare, but important habitat types that are too fine to map at the REA scale and are associated with coarse- (or fine-) filter CEs that could help identify areas where more detailed mapping or surveys are warranted before making land use allocations (such as steppe bluff association with dry aspen forest)?

Description

Rare ecosystems typically occur within micro-climatic niches influenced by site characteristics such as aspect and soil substrate. This question asks us to link rare ecosystems to their associated CE habitats and to identify areas where further rare plant/rare habitat surveys may be warranted.

Methods

To refine rare plant survey methods we will identify unique vegetation communities and associated rare plant species using additional datasets shown below (Table 16). In addition, a literature review of life history traits and habitat characteristics of rare plants and rare ecosystems will be done to associate with Coarse-Filter CEs. We will develop a map of known rare ecosystems associated with Coarse-Filter CEs (Figure 20).

Table 16. Summary of additional datasets for MQ AH1.

Dataset Name	Data Source	Status
Alaska Rare Ecosystem Database	Alaska Natural Heritage Program	Obtained
Alaska Rare Plant Database	Alaska Natural Heritage Program	Obtained

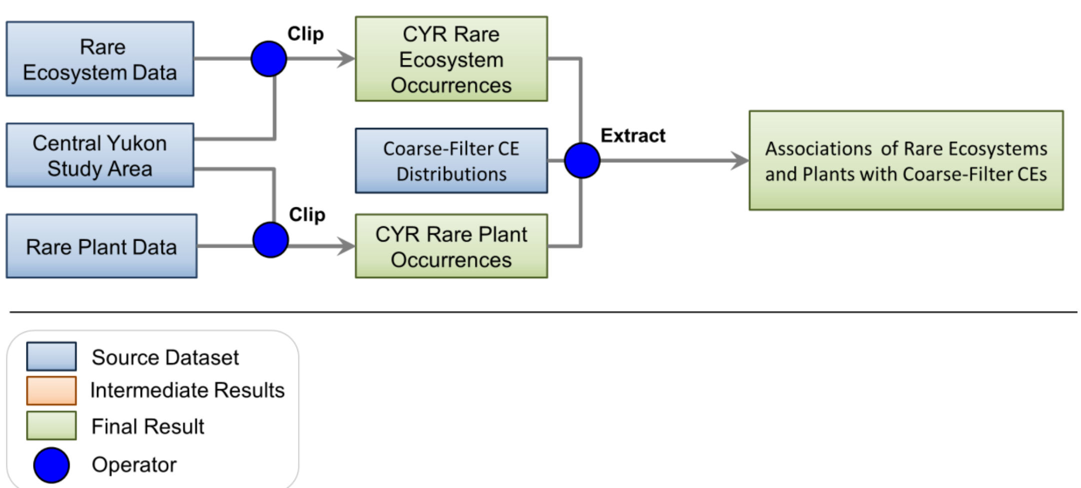

Figure 20. Process model for analysis of associations of rare plant habitats and rare ecosystems with Coarse-Filter CEs (MQ AH1).

Limitations

There are inherent data gaps in rare plant and rare ecosystems databases. Refer to MQ G2 for additional limitations.

How reliable are these predictions?
Reliability of results is limited by quality of input datasets.

Are there other data/models which provide information that is different than the output presented?
There are no other data sets to address this question.

MQ G1: Where are refugia for unique vegetation communities (e.g. hotsprings, bluffs, sand dunes) and what are the wildlife species associated with them?

Description
Rare ecosystems support unique vegetation communities and can support wildlife species. For example, tidal mudflats behind barrier islands are excellent habitat for birds.

Methods
We will map known locations of rare ecosystems and rare plant occurrence data (Table 17). A literature review and the wildlife occurrence dataset will be used to determine wildlife species associations with rare ecosystems. A final product will be a map of known locations, list of species and communities (Figure 21).

Table 17. Summary of additional datasets for MQ G1.

Dataset Name	Data Source	Status
Alaska Rare Ecosystem Database	Alaska Natural Heritage Program	Obtained
Alaska Rare Plant Database	Alaska Natural Heritage Program	Obtained
Fine-filter CE distributions	Alaska Natural Heritage Program	Processing

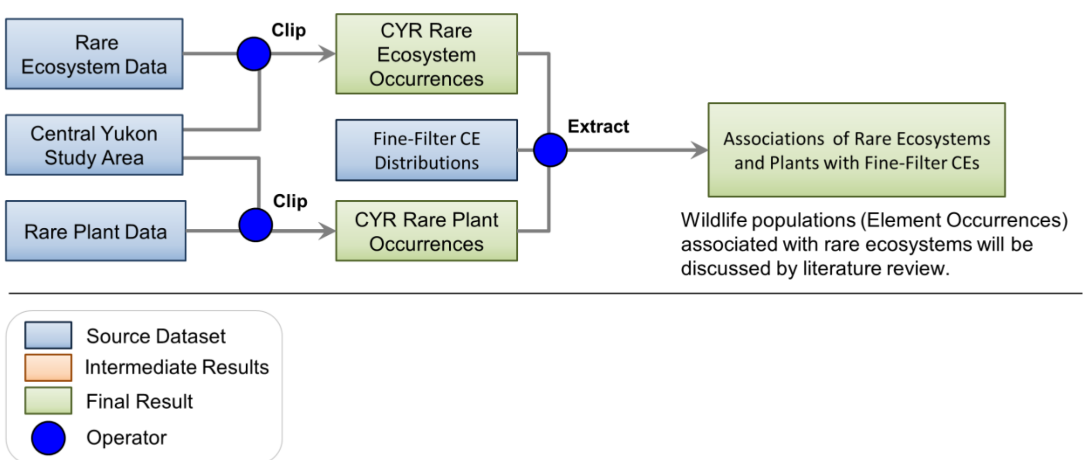

Figure 21. Process model for identification of refugia of unique vegetation communities and the associated wildlife species (MQ G1).

Limitations
There are inherent data gaps in rare plant and rare ecosystems databases. Refer to MQ G2 for additional limitations.

How reliable are these predictions?

Reliability of results is limited by quality of input datasets.

Are there other data/models which provide information that is different than the output presented?

There are no other data sets to address this question.

MQ G2: Which unique vegetation communities (and specifically, which rare plant species) are most vulnerable to significant alteration due to climate change?

Description

Changes in climate are expected to alter habitat conditions which may shift species distributions or extirpate populations. Rare plant species are of particular concern due to their natural risk of extinction. Rare plants may be intrinsically vulnerable to changes in climate due to their limited geographic ranges, small population sizes, habitat specificity, and other natural history traits.

Methods

We will identify unique vegetation communities and associated rare plant species using additional datasets shown below (Table 18). Current and future distribution models of rare plant habitat will be created based on rare plant/ecosystem and climate change datasets. Review of vulnerability will also incorporate a review of the ecology and life history characteristics of the modeled species (e.g., changes in distribution range and components of plant life history traits such as dispersal mechanism and soil specificity will determine sensitivity to changes in climate and habitat shifts) (Figure 22).

Table 18. Summary of additional datasets for MQ G2.

Dataset Name	Data Source	Status
Alaska Rare Ecosystem Database	Alaska Natural Heritage Program	Obtained
Alaska Rare Plant Database	Alaska Natural Heritage Program	Obtained

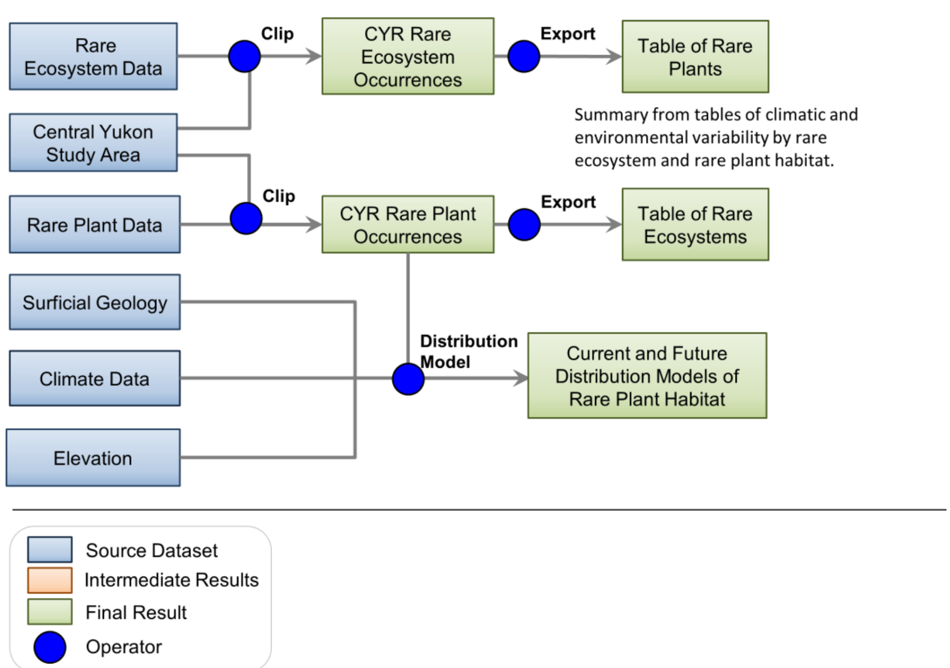

Figure 22. Process model for the assessment of vulnerability of unique vegetation communities to significant alteration due to climate change (MQ G2).

Limitations

Some rare plant data originates from herbaria specimens that may contain less precise locality data. Additionally, while point data may indicate a species occurrence, the lack of point data does not indicate absence. Surficial geology maps and topography may not have the fine resolution associated with species distribution.

How reliable are these predictions?

Climate change predictions are based on SNAP modeling. See appropriate section for assumptions and reliability. The limitations with MaxEnt modeling coincide with the limitations of the quality of data inputs, however it does not rely on absence data making this a more robust model. Additionally, it is difficult to model fine habitat niches on a regional scale.

Are there other data/models which provide information that is different than the output presented?

No other data exists for rare plant or rare ecosystems for Alaska. See climate sections for other climate data/models. CRT (classification and regression tree) modeling for habitat suitability is an alternative method. However, MaxEnt is more widely used, easier to simulate, and easier to compare results with other scientific studies. An alternative method for identifying species vulnerable to climate change is to use the NatureServe Climate Change Vulnerability Index. However, this index requires specific moisture data that is not available for Alaska.

MQ AE1: Where is primary waterfowl habitat located?

Description

Alaska's wetlands provide nesting habitat for approximately 20% of America's waterfowl species' (FWS 2010). Approximately 32% of the CYR study area is classified as wetland habitat. For this management question we will identify wetland type and prevalence throughout the CYR study area as an indicator of primary waterfowl habitat.

Methods

Wetland classes in the CYR study area will be extracted from the Alaska Wetlands Map (AKNHP). Relevant wetland classes will be cross-walked with waterfowl species in the GAP Analysis habitat association database to develop a list of relevant waterfowl species in each area (Figure 23).

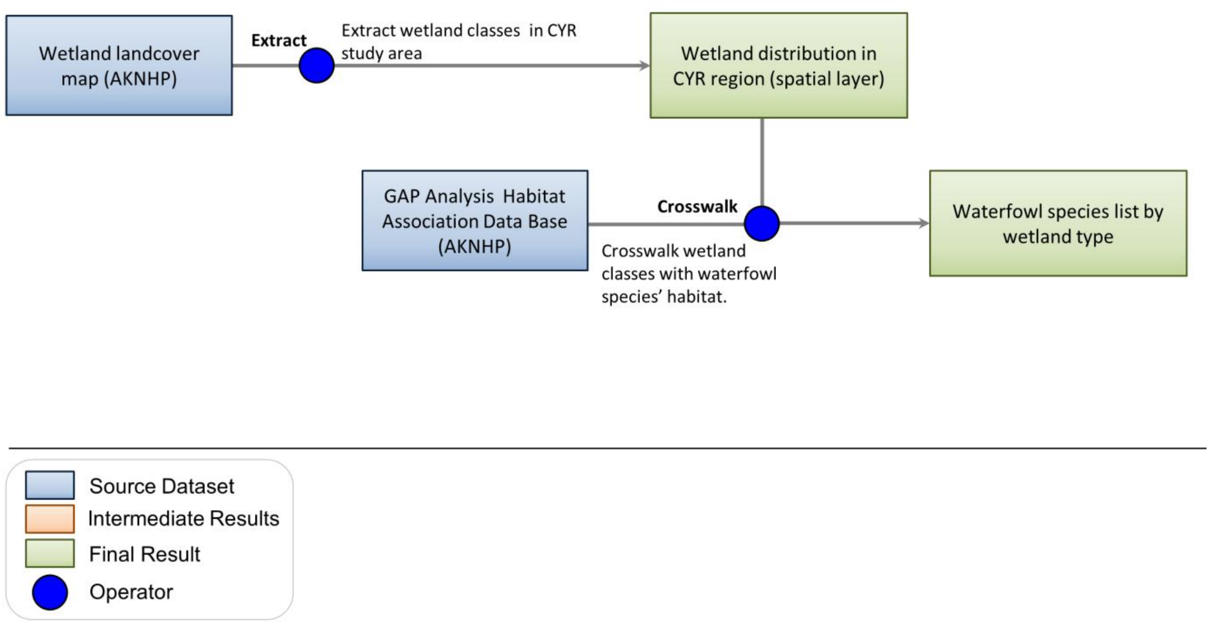

Figure 23. Process model for the classification of waterfowl habitat (MQ AE1).

Limitations

How reliable are these predictions?

These predictions are based on a relatively coarse analysis that relies heavily on the wetland classification layer. Variables such as water depth or temperature, climate, or other factors that may affect waterfowl success are not considered, however, these predictions provide a good overall picture of where waterfowl nesting habitat occurs throughout the CYR study area.

Are there other data/models which provide information that is different than the output presented?

Other surveys have identified specific nesting areas for particular waterfowl in the region (e.g. Conant et al 2002). We will assess how well our wetland delineations align with other survey results.

MQ L1: What are caribou seasonal distribution and movement patterns?

Description

Caribou are migratory mammals that undertake seasonal movements between preferable habitats such as calving grounds, summer insect relief areas and areas of seasonal forage availability. There are thirty-one caribou herds in Alaska, twelve of which have ranges that overlap with, or are contained within the CYR study area. Understanding where herds typically range throughout the year is essential for monitoring herd behavior and health, and may be important when considering future development and the potential introduction of domestic reindeer herds to the area. For this management question we will define winter, summer and when possible, calving ranges for each caribou herd in the CYR region. We will also attempt to describe movement patterns between seasonal ranges.

Methods

The Alaska Habitat Management Guide (ADF&G 1985) depicts seasonal caribou herd ranges throughout Alaska. We will use these maps to delineate and digitize caribou seasonal distribution and seasonal movements by herd. These ranges will undergo expert review to confirm or adjust the depicted ranges. In addition, if available, we will use radio collar data to identify seasonal movement corridors and patterns (Figure 24).

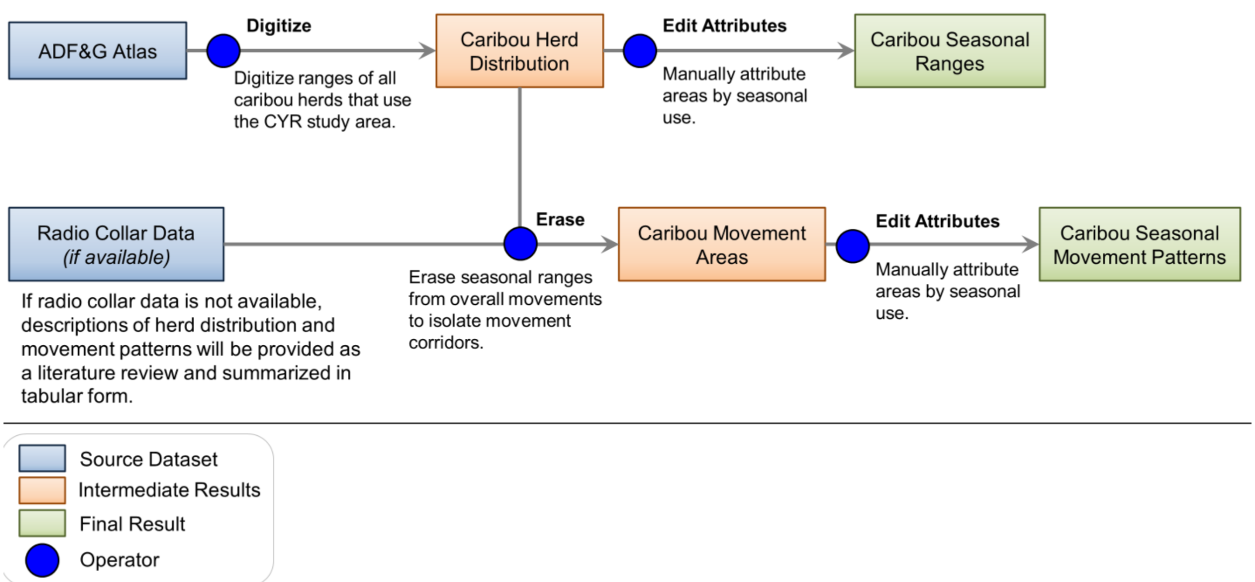

Figure 24. Process model for the delineation of caribou seasonal distribution and movement patterns (MQ L1).

Limitations

How reliable are these predictions?

These data are considered accurate and reliable in terms of identifying general seasonal distributions and movement patterns.

Are there other data/models which provide information that is different than the output presented?

Other data not used in this process include radio collar data (ADF&G). These data would further identify migration corridors used by caribou travelling between seasonal grounds.

MQ N3: How might sheep distribution shift in relation to climate change?

Description

Dall sheep habitat is defined by rugged terrain, alpine land cover, and snow depth less than 30 cm (winter habitat). For this management question we will model future shift in sheep distribution using terrain, climate-related vegetation shifts and predicted snow depths in the CYR study area.

Methods

Change in potential sheep habitat will be assessed using vegetation shifts and winter snow depths. The sheep distribution model (developed using GAP model and radio collar data) will be overlaid with the current (2010's) vegetation layer to identify preferred habitat types in the CYR study area. These preferred vegetation classes (typically alpine) will be extracted from the current (2010's) vegetation map. ALFRESCO will be used to predict areas of shrubline and treeline advancement (habitat reduction). The 'current available forage / habitat' layer will be subtracted from the 'future available forage / habitat' layer to produce a 'change in available habitat and suitable forage' layer (Figure 25).

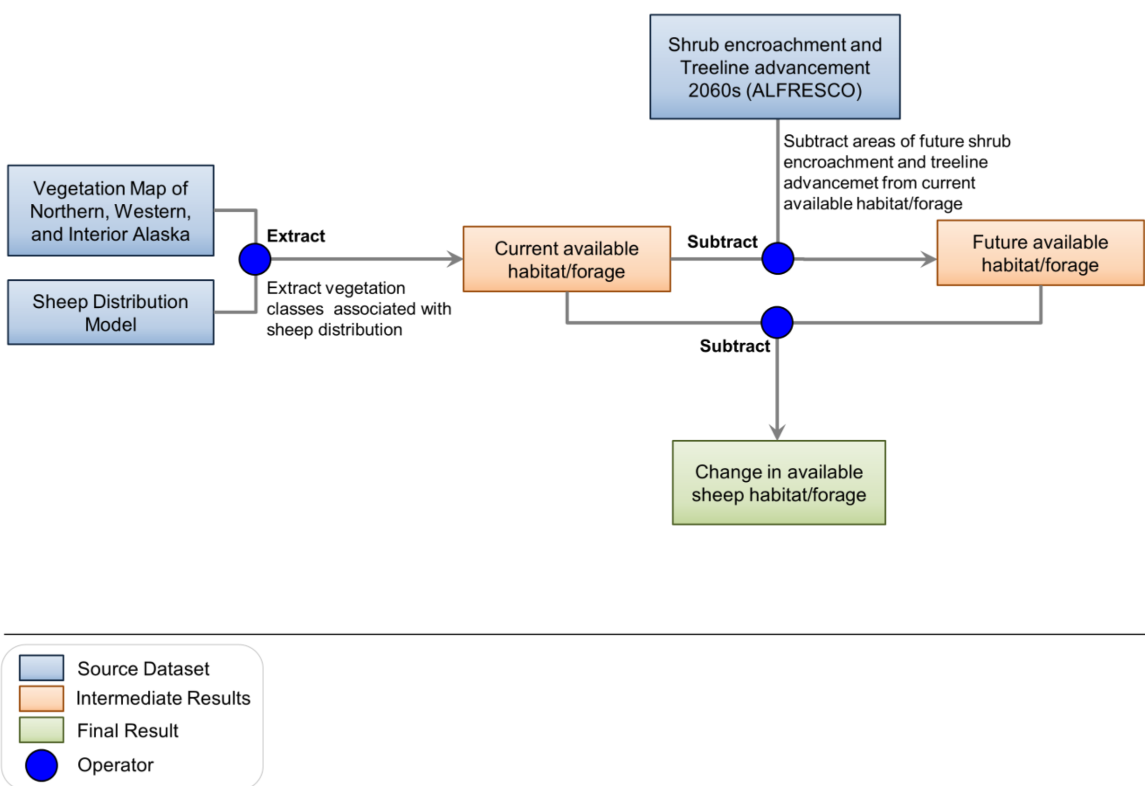

Figure 25. Process model for analysis of future annual potential sheep habitat and change in future availability of sheep forage (MQ N3).

Limitations

How reliable are these predictions?

This analysis will provide a general overview of trends in potential habitat and distribution changes; however, the vegetation layer is at a coarse scale, preventing fine scale analysis. In addition, snow depth data which would further define winter ranges are not available for analysis at this time.

Are there other data/models which provide information that is different than the output presented?

We are unaware of any other models that provide information on this topic.

MQ T1: The introduction of free-ranging reindeer herds to this region has been proposed. What areas would be most likely to biologically support a reindeer herd?

Description

Domestic reindeer herds were introduced to Alaska as a source of meat and economic development for the Inupiaq in the late 1800's. Today, majority of the domestic mainland herds (totaling approximately 20,000 reindeer) are located in western Alaska and grazing permits are issued to herders for ranges averaging 4000 hectares in size. Reindeer forage on similar items to caribou, with lichens as the primary winter food preference (Olofsson et al. 2011). Free-ranging herds require approximately 30 acres of winter grazing ground per individual (Epstein and Valmari 1984). Using these forage and range size restrictions, we will identify areas in the CYR region that are most likely to support free-ranging reindeer herds. We will also consider the current range locations and movement patterns of wild caribou herds in the region since reindeer will often follow a caribou herd on its migration, resulting in devastating losses for the herder (Jernslettern and Klokov 2002).

Methods

Using the Alaska landcover map (AKNHP), we will identify vegetation classes that contain reindeer forage, and classify each class as 'poor', 'moderate' or 'good' quality for both summer and winter forage. To identify areas large enough to support a reindeer herd, we will extract areas of greater than 4000 hectares of connected habitat classified as 'good' forage (Figure 26).

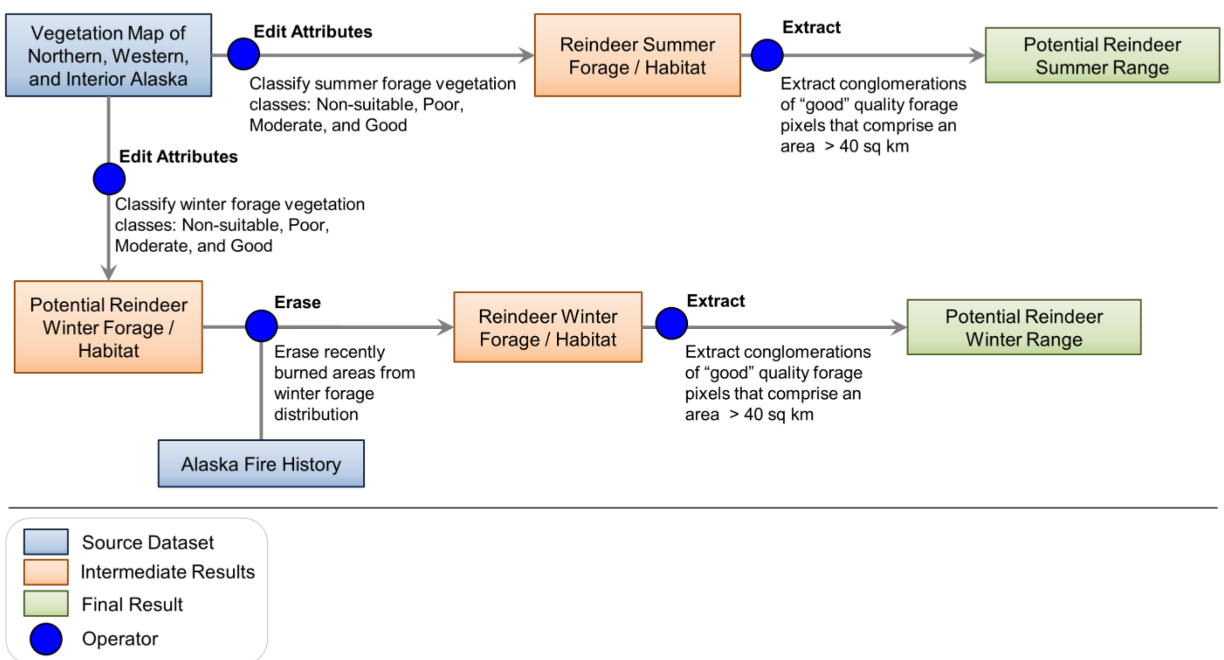

Figure 26. Process model for analysis of potential reindeer habitat (MQ T1).

Limitations
Analysis is limited to the resolution of the vegetation layer.

How reliable are these predictions?
These predictions provide a general overview of areas with potential forage and area to biologically support a reindeer herd. A more detailed study using ecological site descriptions (Swanson et al. 1985) and nutritional characteristics of reindeer forage (Finstad 2008) in the identified areas would provide a more refined and accurate analysis of potential reindeer ranges. This fine-scale analysis is beyond the scope of this REA.

Are there other data/models which provide information that is different than the output presented?
Swanson et al. (1985) performed a study detailing ecological site descriptions throughout the Seward Peninsula using soil properties, hydrology and plant community characteristics such as composition, ground cover, structure of canopy cover and annual production. Finstand (2008) developed nutritional maps for grazing areas on the Seward Peninsula using nutrient and fiber profiles of reindeer forage plants. Both of these studies exhibit a more detailed approach to identifying viable reindeer ranges.

MQ X1: What have the past cumulative impacts of road construction and mineral extraction been on terrestrial CE habitat and population dynamics?

Description

Road construction and mineral extraction can impact animal habitat and population dynamics (e.g. Dyer et al 2001, Trombulak and Frissell 2001, Weir et al 2007). Past impacts of road construction, mineral extraction and the infrastructure associated with mineral extraction on CE habitat and population dynamics will be analyzed. We will assess harvest pressure as a driver of population dynamics for game species (caribou, moose, sheep).

Methods

An extensive literature review will be performed to identify general impacts of road construction and mineral extraction on terrestrial CE habitat and population dynamics including reproductive success and population densities.

Spatial analysis will include:

1) Habitat – Areas of past/current mining development, including roads, all current hard rock mines boundaries, all current hard rock mines ancillary infrastructure and all placer mining activity, will be extracted from each current terrestrial CE habitat (i.e. GAP models, seasonal range maps, etc.), creating layers highlighting areas of high human impact on potential CE distributions. A table of % modeled habitat affected by mining and road areas will be developed (Figure 27).

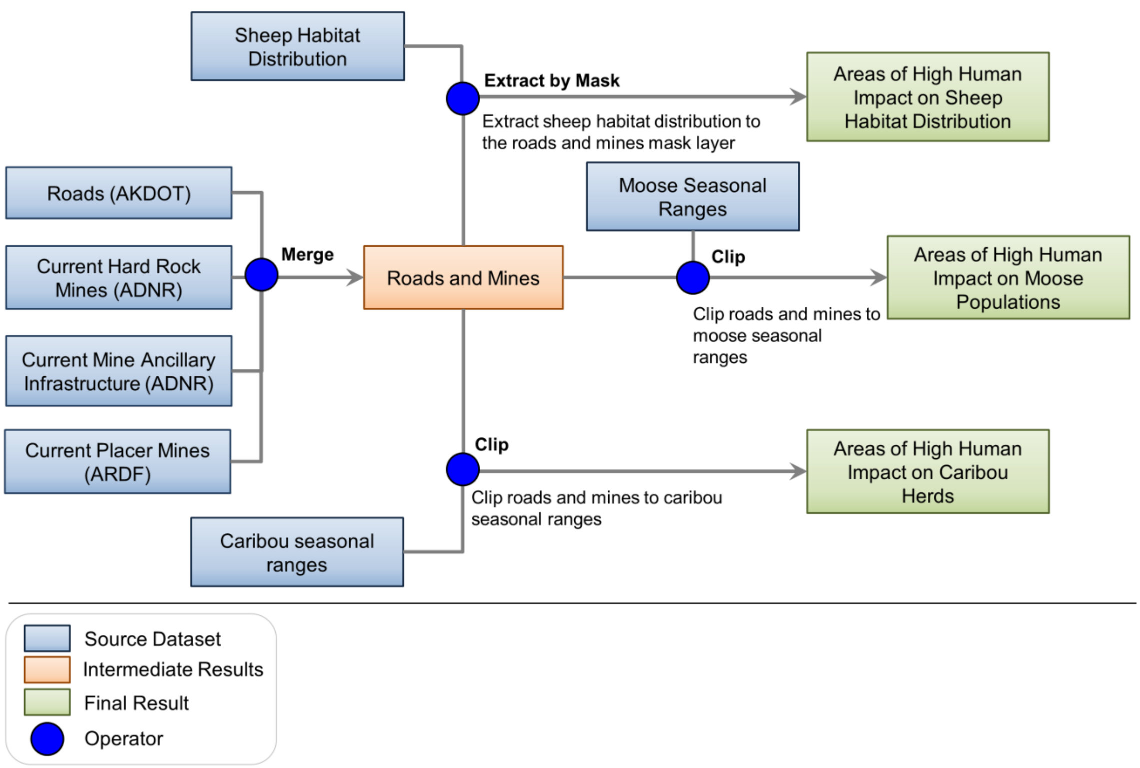

Figure 27. Process model for analysis of past cumulative impacts of road construction and mineral extraction on Terrestrial Fine-Filter CE habitats (MQ X1).

2) Population dynamics – Game population numbers (derived from literature review), mining development (past and current roads and active mines), and harvest (subsistence and sport) densities will each be calculated by game management unit (GMU), creating density layers by GMU (Figure 28).

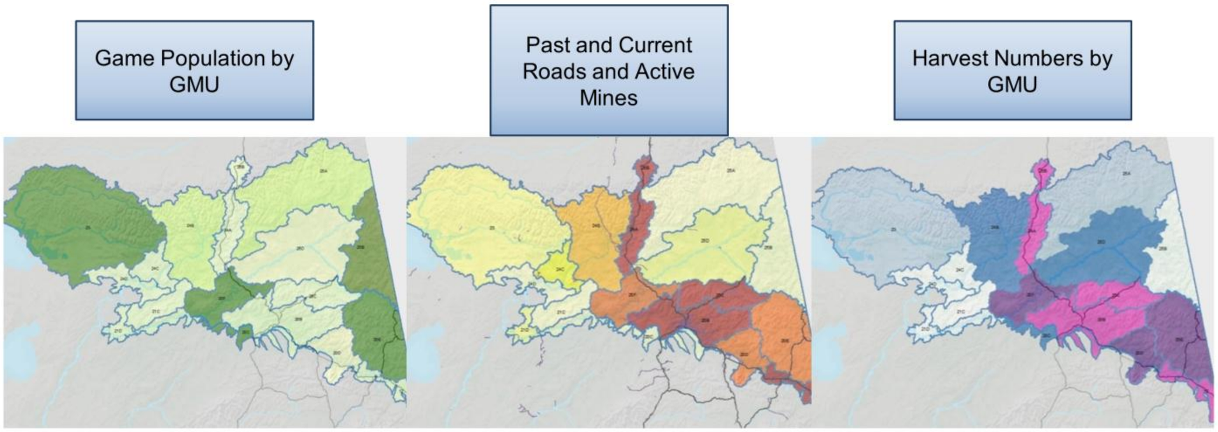

Figure 28. Example maps depicting game population, human development, and harvest densities per GMU. Darker colors indicated heavier densities (these are examples only, no real data were used).

The correlation between subsistence harvest (controlling for game population size) and road density will be tested across GMUs. We would hypothesize that if road construction and mineral extraction increase harvest accessibility then there will be a significant correlation (Figure 29).

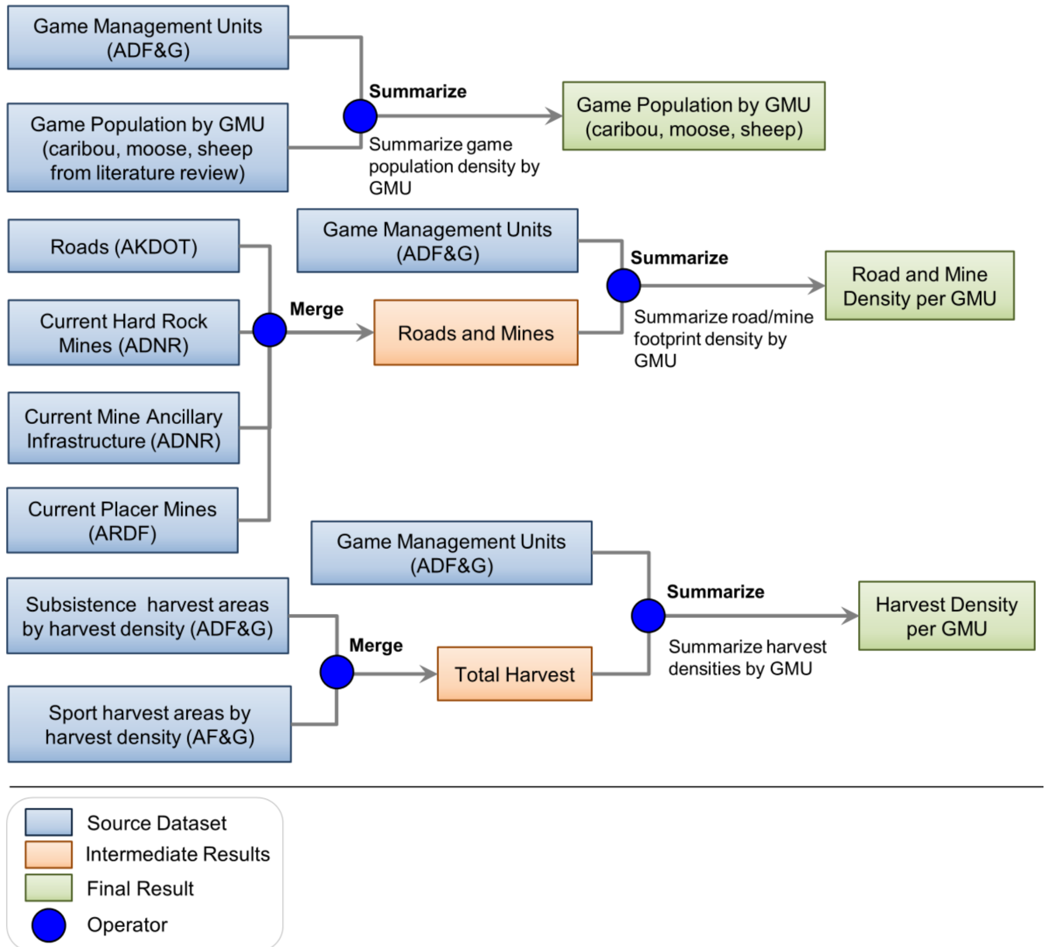

Figure 29. Process model for analysis of game population, road and mine development, and harvest per GMU (MQ X1).

Limitations

While hunting and fishing is reported by aggregate units, exact location data of either hunting or fishing for any species is limited or unavailable. In addition, the ADF&G surveys are not conducted every year in every community, and large gaps exist in the available data. Spatial data on subsistence use areas is available for one or two years for a limited number of communities. Given the large data gaps, this data is only as reliable as its coverage over time and across the geography. Data for different types of hunts are available at varying geographic scale. While the subsistence data derived from a household sample at a community level, the sport and commercial fishing and hunting is a 100% count.

How reliable are these predictions?

Our population dynamic analysis considers hunting/harvest as a primary driver. It does not include climatic or seasonal variations which may also influence population dynamics for certain populations.

Are there other data/models which provide information that is different than the output presented?

We are unaware of any other models that provide information on this topic.

MQ X2: How might future road construction and mineral extraction infrastructure (e.g. both temporary and permanent roads [Umiat, Ambler, Stevens Village], pads, pipeline, both permanent and temporary) affect species habitat, distribution, movements and population dynamics (especially caribou, moose, sheep)?

Description
This management question builds upon MQ X1 in predicting how future road construction and mining activity may affect terrestrial CE habitat, distribution, movements and population dynamics.

Methods
An extensive literature review will be performed to identify general impacts of road construction and mineral extraction on movement and population dynamics of each terrestrial CE, focusing on habitat fragmentation and species-specific sensitivity to disturbance (MQ X1).

Proposed roads, proposed hard rock mine boundaries, proposed hard rock mine ancillary infrastructure and proposed placer mining activity layers will be overlaid to create a “future roads and mining activity” layer. Distribution models and seasonal ranges of sheep, moose and caribou will be extracted from the future roads and mining activity layer to identify areas of high impact. When applicable, a special emphasis will be placed on breeding areas to address issues of population dynamics (Figure 30).

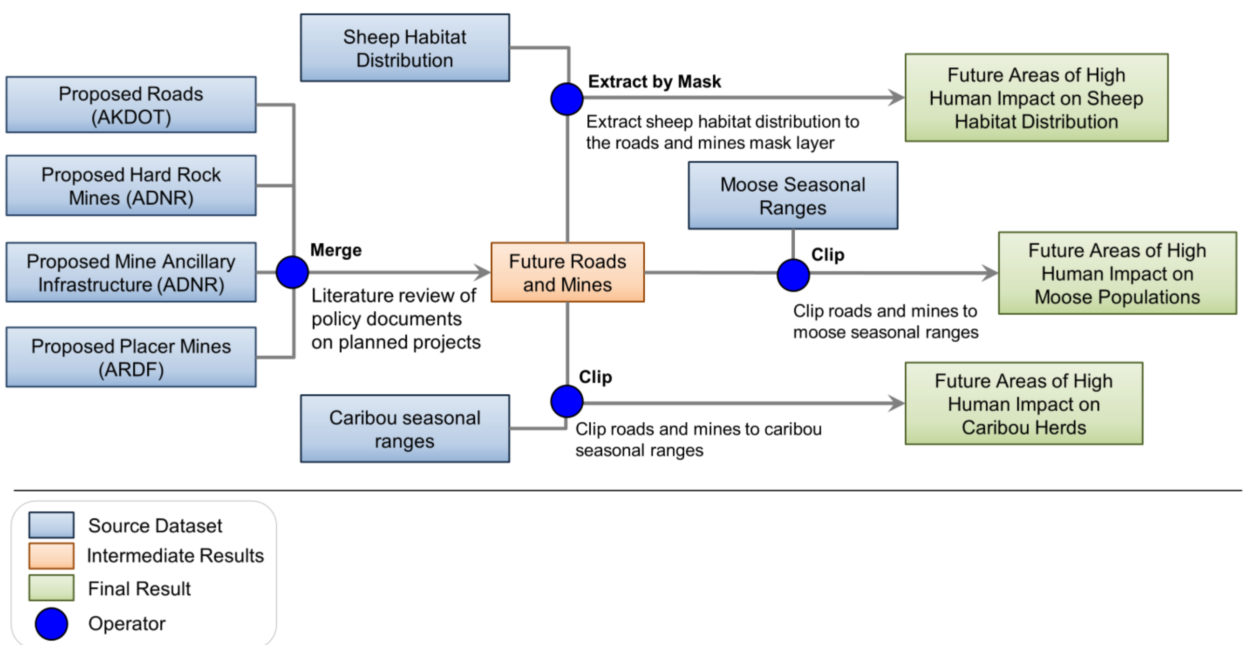

Figure 30. Process model for analysis of future cumulative impacts of road construction and mineral extraction on Terrestrial Fine-Filter CE habitats (MQ X2).

Limitations

How reliable are these predictions?
Projecting future mineral extraction activities are highly speculative. The probability of mine development depends not only on the availability of the mineral but also on the market feasibility of its extraction. Several social and economic forces beyond the control of any regulatory authority influence future mining activity, and for this reason, unless a mine is at least in exploratory phase, it is not advisable to add it to the database of future mines. However, a database of prospects will be compiled and submitted, and can be used with the model in the future.

Are there other data/models which provide information that is different than the output presented?
We are unaware of any other models that provide information on this topic.

MQ W2: How might future road construction and mineral extraction infrastructure (e.g. both temporary and permanent roads, pads, pipeline) affect fish habitat, fish distribution, and fish movements (especially chinook, chum, sheefish)?

Description

While most infrastructure for these activities are expected to be temporary, the life span of these activities and some of the associated infrastructure can last several decades, with substantial impact on many species including fish. Future infrastructure will be identified based on set criteria that indicate some reasonable chance of the infrastructure actually being built. In other words, speculative projects with no concrete evidence or documentation would not be included.

Methods

Spatial analysis - Fish habitats will be identified using all CE fish occurrence distribution data that we will obtain from the arctic and interior Anadromous Waters Catalog for CE species (Chinook, chum, sheefish) and clipped to the CYR study area.

Future human footprint data will be compiled from review of policy documents to identify any planned developments. Planned developments will be identified using thresholds of feasibility. Information from numerous sources including Department of Transportation, Department of Alaska Fish and Game, Bureau of Land Management, Division of Mining, Land, and Water, Department of Environmental Conservation and other state, federal, and local sources will be utilized.

These source datasets will be overlaid to identify areas that mineral and gravel extraction activities occur, or have the potential to occur in relation to fish and riparian habitat. We will produce a map that represents these data spatially. We will also conduct spatial analyses that include intersecting the development data with the fish distribution data and the riparian habitat data in order to quantify the amount of fish habitat and riparian habitat (as a percentage or area value) that could potentially be affected in the future (Figure 31).

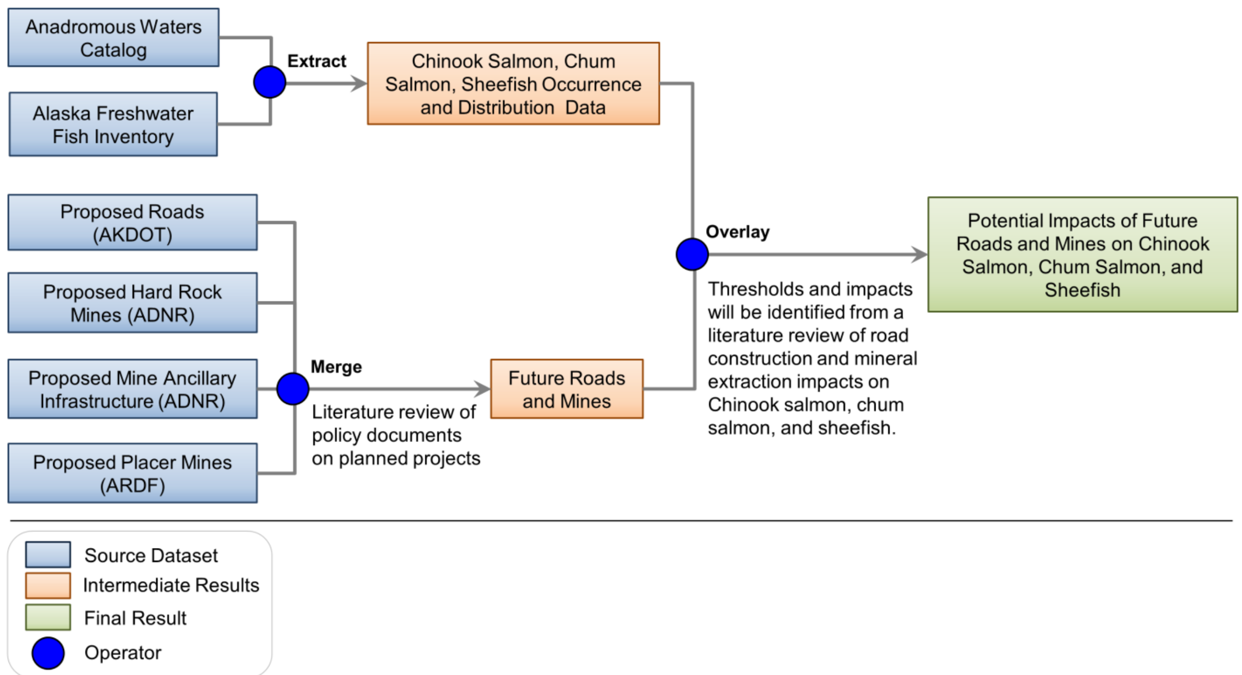

Figure 31. Process model for analysis of effects of road construction and mineral extraction infrastructure on fish habitat, distribution, and movements (MQ W2).

Literature review - The second part to this question will entail a literature review of the impacts of road construction and mining on fish habitat, fish distribution, and fish movements. We will focus our literature review on the select CE fish species (Chinook, chum, and sheefish). However, it is likely that the literature will be general to fish species. If we do not find specific information regarding these select species, we will instead keep the review to a general overview of these types of human development impacts on fish.

Limitations

Our biggest limitation in answering this question will be our spatial analyses. Fish occurrence data is not comprehensive for the CYR study area and we do not have absence data. Therefore we lack the ability to accurately model fish species distributions, which inhibits our ability to predict future changes to habitats and distributions.

Data on gravel extraction may not be easily available or be comprehensive. Our attempts so far to identify and collect data on gravel extraction activities in the region haven't been fruitful. The DNR-Division of Mining Land & Water does not permit gravel extraction. Gravel extraction is a common activity across the state and the quantity extracted varies greatly. Gravel is treated as part of the surface estate, or sub-surface estate depending on the ownership of the land. Associated regulations govern the permitting process for gravel extraction. The only state agency that monitors permitting for gravel extraction is the Division of Water within the Department of Environmental Conservation, stemming from their oversight of surface and ground water quality. The project team is in the process of obtaining any data available on gravel site operations in CYR region.

How reliable are these predictions? These predictions will be very coarse (see limitations).

Are there other data/models which provide information that is different than the output presented? We are not aware of any other models for the CYR that would similarly answer this question.

MQ V1: How does human activity (e.g. mineral extraction, gravel extraction) alter stream ecology and watershed health (i.e. water quantity, water quality, outflow/stream connectivity, fish habitat, and riparian habitat)?

Description

Human activities such as mineral and gravel extraction can affect several attributes of water bodies as well as fish species and riparian habitats associated with these waterbodies. This question is focused on overall watershed health in the wake of mineral extraction or gravel extraction. The Division of Mining Land and Water, located within Alaska's Department of Natural Resources, issues permits for these activities, thus we will be able to spatially identify the locations of most extraction in relation to waterbodies and fish habitat. The Division of Water, located within the Department of Environmental Conservation issues and manages the multi-sector general permits that govern gravel extraction in Alaska. However, it is not clear at this time if these permits govern gravel pits regardless of land ownership.

Methods

Spatial analysis - Fish habitats will be identified using fish occurrence data from the arctic and interior Anadromous Waters Catalog (Chinook, chum, and sheefish) and the Alaska Freshwater Fish Inventory (northern pike, humpback whitefish, Dolly Varden). Claims, prospects, and active mining sites will be obtained from Division of Mining, Land, and Water. Placer mining data will be obtained from the Alaska Resource Data File (ARDF). These source datasets will be overlaid to provide information on the spatial extent of the potential impacts that mineral extraction activities could have on watershed health within the CYR study area. We will only use data from mineral and gravel extraction permits that indicate this activity has occurred. Information on gravel permits is limited to the permits issued by Alaska Division of Mining, Land, and Water.

We will produce a final map that represents these combined datasets spatially. We will also conduct spatial analyses that include intersecting the development data with the fish distribution data in order to quantify the amount of fish habitat (as a percentage or area value) that could potentially be affected in the future (Figure 32).

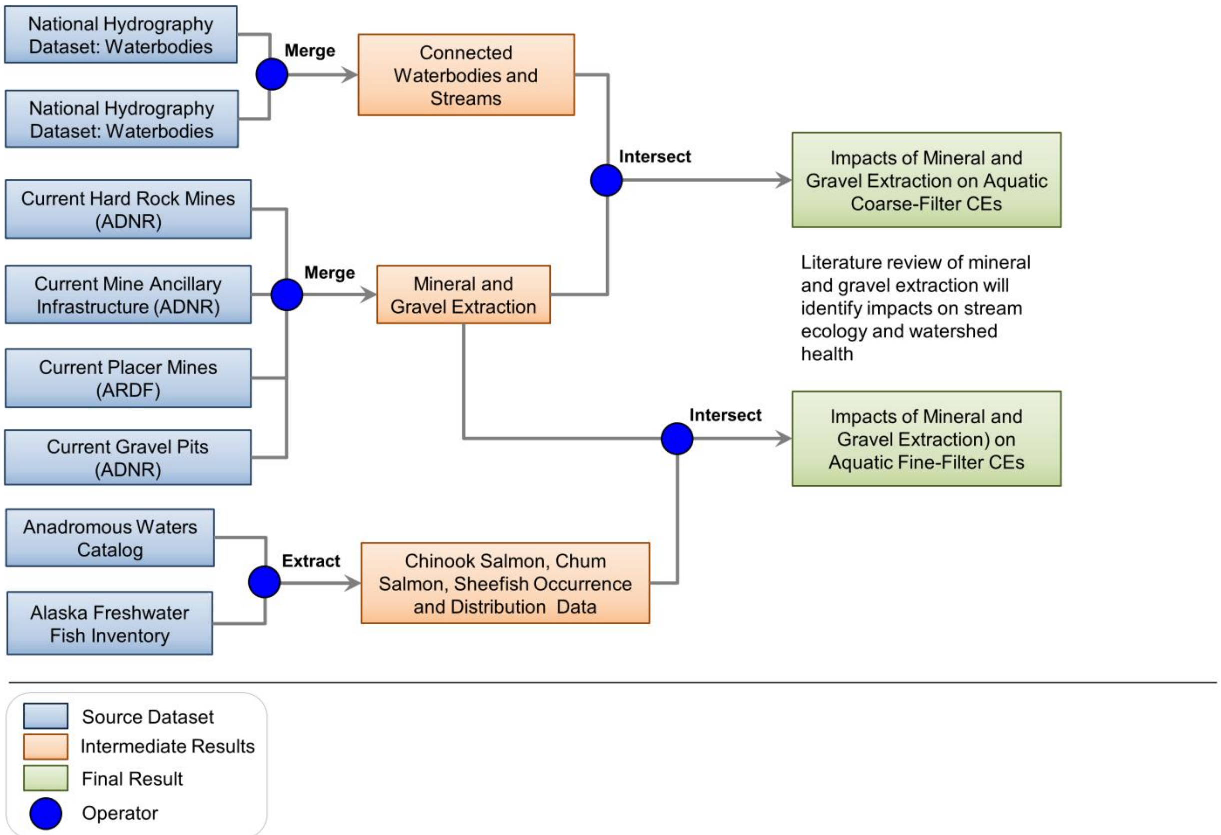

Figure 32. Process model for analysis of effects of mineral and gravel extraction on stream ecology and watershed health (MQ V1).

Literature review - The second part to this question will entail a literature review of the impacts of gravel extraction and mining on water quantity, water quality, outflow/stream connectivity, fish habitat, and riparian habitat. We will focus our literature review on the select CE fish species (Chinook, chum, and sheefish). However, it is likely that the literature will be general to fish species. If we do not find specific information regarding these select species, we will instead keep the review to a general overview of these types of human development impacts on fish.

Limitations

Our biggest limitation in answering this question will be our spatial analyses. We do not have fish habitat specific data. Instead, we have fish occurrence data and we only have presence data (absence data lacking). Thus, we lack the ability to accurately model fish habitats which limits our ability to predict future changes to habitats. Data on gravel extraction may not be easily available or be comprehensive. Our attempts so far to identify and collect data on gravel extraction activities in the region haven't been fruitful. The DNR-Division of Mining Land & Water does not permit gravel extraction. Gravel extraction is a common activity across the state and the quantity extracted varies greatly. Gravel is treated as part of the surface estate, or sub-surface estate depending on the ownership of the land. Associated regulations govern the permitting process for gravel extraction. The only state agency that monitors permitting for gravel extraction is the Division of Water within the Department of Environmental Conservation, stemming from their oversight of surface and ground water quality. The project team is in the process of obtaining any data available on gravel site operations in CYR region.

How reliable are these predictions? These predictions will be very coarse (see Limitations).

Are there other data/models which provide information that is different than the output presented? We are not aware of any other models for the CYR that would similarly answer this question.

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Appendix A: Datasets Selected for CYR REA

All datasets selected for the spatial analyses proposed for the CYR REA are listed in this table. Datasets are listed in the order of their appearance within this document and are therefore arranged primarily by thematic grouping (CAs, CEs, and MQs).

CA / CE / MQ	Dataset Name	Data Source	Status
Climate	Five Model Decadal Standard Deviation in Temperature (A2, 2 km grid)	Scenario Network for Alaska and Arctic Planning	Processed
Climate	Five Model Decadal Standard Deviation Precipitation (A2, 2 km grid)	Scenario Network for Alaska and Arctic Planning	Processed
Climate	Historical Decadal Averages of Annual Total Precipitation 1910-1999 (771 m grid)	Scenario Network for Alaska and Arctic Planning	Processed
Climate	Historical Decadal Averages of Seasonal Total Precipitation 1910-1999 (771 m grid)	Scenario Network for Alaska and Arctic Planning	Processed
Climate	Historical Decadal Averages of Monthly Mean Temperatures (771 m grid)	Scenario Network for Alaska and Arctic Planning	Processed
Climate	Historical Decadal Averages of Annual Mean Temperatures (771 m grid)	Scenario Network for Alaska and Arctic Planning	Processed
Climate	Historical Decadal Averages of Seasonal Mean Temperatures (771 m grid)	Scenario Network for Alaska and Arctic Planning	Processed
Climate	Projected Decadal Averages of Monthly Mean Temperatures (A2, 771 m grid)	Scenario Network for Alaska and Arctic Planning	Processed
Climate	Projected Decadal Averages of Annual Mean Temperatures (A2, 771 m grid)	Scenario Network for Alaska and Arctic Planning	Processed
Climate	Projected Decadal Averages of Seasonal Mean Temperatures (A2, 771 m grid)	Scenario Network for Alaska and Arctic Planning	Processed

CA / CE / MQ	Dataset Name	Data Source	Status
Climate	Projected Decadal Averages of Annual Total Precipitation (A2, 771 m grid)	Scenario Network for Alaska and Arctic Planning	Processed
Climate	Projected Decadal Averages of Seasonal Total Precipitation (A2, 771 m grid)	Scenario Network for Alaska and Arctic Planning	Processed
Climate	Projected Day of Freeze (A2, 771 m grid)	Scenario Network for Alaska and Arctic Planning	Processed
Climate	Projected Day of Thaw (A2, 771 m grid)	Scenario Network for Alaska and Arctic Planning	Processed
Climate	Projected Length of Growing Season (A2, 771 m grid)	Scenario Network for Alaska and Arctic Planning	Processed
Climate	Alaska Projected Decadal Averages of Monthly Snow-day Fraction (A2, 771 m grid)	Scenario Network for Alaska and Arctic Planning	Processed
Climate	Projected Alaska Climate-Biome Shift (A2, 2 km grid)	Scenario Network for Alaska and Arctic Planning	Processed
Fire	Projected (2006-2100) ALFRESCO outputs	Scenario Network for Alaska and Arctic Planning	Processed
Fre	Alaska Fire History datasets	BLM	Processed
Permafrost	Mean annual ground temperature 2010s, 2020s, and 2060s (A2, 2 km grid)	Scenario Network for Alaska and Arctic Planning	Processed
Permafrost	Active layer thickness 2010s, 2020s, and 2060s (A2, 2 km grid)	Scenario Network for Alaska and Arctic Planning	Processed
Invasive Species	Alaska Exotic Plants Information Clearinghouse (AKEPIC)	Alaska Natural Heritage Program	Processed
Insects and Disease	Aerial Damage Survey Alaska 1989	USGS Forest Health Monitoring Clearinghouse	Processed
Insects and Disease	Aerial Damage Survey Alaska 1990	USGS Forest Health Monitoring Clearinghouse	Processed
Insects and Disease	Aerial Damage Survey Alaska 1991	USGS Forest Health Monitoring Clearinghouse	Processed

CA / CE / MQ	Dataset Name	Data Source	Status
Insects and Disease	Aerial Damage Survey Alaska 1992	USGS Forest Health Monitoring Clearinghouse	Processed
Insects and Disease	Aerial Damage Survey Alaska 1993	USGS Forest Health Monitoring Clearinghouse	Processed
Insects and Disease	Aerial Damage Survey Alaska 1994	USGS Forest Health Monitoring Clearinghouse	Processed
Insects and Disease	Aerial Damage Survey Alaska 1995	USGS Forest Health Monitoring Clearinghouse	Processed
Insects and Disease	Aerial Damage Survey Alaska 1996	USGS Forest Health Monitoring Clearinghouse	Processed
Insects and Disease	Insect Damage Survey Explorer Alaska 1997 to 2012	USFS Forest Health Protection Insect Damage Survey Explorer	Processed
Insects and Disease	Aerial Damage Survey Alaska 2013	Tom Heutte, USFS State & Private Forestry	Processed
Insects and Disease	Aerial Damage Survey Alaska 2014	Tom Heutte, USFS State & Private Forestry	Processed
Insects and Disease	Insect Damage Survey Explorer Alaska Flight Paths 1999 to 2012	USFS Forest Health Protection Insect Damage Survey Explorer	Processed
Insects and Disease	Aerial Damage Survey Flight Paths 2013	Tom Heutte, USFS State & Private Forestry	Processed
Insects and Disease	Aerial Damage Survey Flight Paths 2014	Tom Heutte, USFS State & Private Forestry	Requested
Anthropogenic	Total population	U.S. Census, AK DOLWD	Obtained
Anthropogenic	Population by sex by age group	U.S. Census	Obtained
Anthropogenic	Borough/census area migration	AkDOLWD	Obtained
Anthropogenic	Renewable energy project	AEA, AEDG	Obtained
Anthropogenic	Renewable energy potential	AEA	Obtained
Anthropogenic	Mining activities	ARDF	Obtained
Anthropogenic	Distressed communities	Denali Commission Alaska	Obtained
Anthropogenic	Community gasoline prices	DRCA Research and Analysis Section	Pending
Anthropogenic	Fuel oil price	Alaska Energy Gateway	Obtained
Anthropogenic	Alaska fuel price projections 2014-2040	ISER	Obtained
Anthropogenic	School enrollment	EED, NCES	Obtained
Anthropogenic	Sport game harvest	ADF&G	Pending

CA / CE / MQ	Dataset Name	Data Source	Status
Anthropogenic	Commercial and subsistence salmon harvest	ADF&G	Pending
Anthropogenic	Historic maps, aerial photos of communities	DCRA	N/A
Anthropogenic	Alaska fishery management report	ADF&G	N/A
Anthropogenic	Subsistence harvest	ADF&G, CSIS (Community Subsistence Information System)	Obtained
Anthropogenic	Native allotments	NSB	Obtained
Anthropogenic	Borough and census area boundary files	NSB	Obtained
Anthropogenic	ALARI	AkDoLWD	Obtained
Anthropogenic	PFD	DoR	Pending
Anthropogenic	Supplemental Nutrition Assistance Program (SNAP)	US Census Bureau	N/A
Anthropogenic	Renewable Energy geodatabase	AEA	Obtained
Anthropogenic	Planned & Proposed Infrastructure	AkDoT	Obtained
Anthropogenic	Anadromous Streams	ADF&G	Obtained
Anthropogenic	General Land Status	BLM/DNR	Obtained
Anthropogenic	State Parks	ADNR	Obtained
Anthropogenic	Federal Mining Claims	BLM	Obtained
Anthropogenic	Placer Districts	USGS	Obtained
Anthropogenic	State Mining Claims	ADNR	Obtained
Anthropogenic	State Mining Prospects	ADNR	Obtained
Anthropogenic	Red Dog mine, port, road	ADNR, DoT	Pending
Anthropogenic	Ft Knox mine footprint	ADNR	Pending
Anthropogenic	Pogo mine footprint	ADNR	Pending
Anthropogenic	Usibelli mine footprint	ADNR	Pending
Anthropogenic	Transportation Infrastructure	USGS, AkDoT, ADNR, ADF&G, ISER	Obtained
Anthropogenic	Road from Noatak to deLong road	AkDOT	Pending
Anthropogenic	Kivalina evacuation road	AkDoT	Pending
Anthropogenic	Road to ambler district	AkDoT	Pending
Anthropogenic	NWAB trails	NWAB	Obtained

CA / CE / MQ	Dataset Name	Data Source	Status
Anthropogenic	NWAB subsistence use areas	NWAB	N/A
Anthropogenic	NWAB sensitive ecological areas	NWAB	N/A
Anthropogenic	NWAB Resource Development Opportunity Areas (RDOA)	NWAB	N/A
Anthropogenic	DEC contaminated sites database, including abadoned military sites	ADEC	Obtained
Anthropogenic	Cape Blossom road and port site	ADEC	Pending
Terrestrial Coarse-Filter CEs	Vegetation Map of Northern, Western, and Interior Alaska	Alaska Natural Heritage Program	Obtained
Terrestrial Coarse-Filter CEs	National Landcover Database	Multi-Resolution Land Characteristics Consortium	Obtained
Terrestrial Coarse-Filter CEs	Surficial Geology of Alaska	Alaska Permafrost Map	Obtained
Terrestrial Coarse-Filter CEs	Circumboreal Vegetation Map	Conservation of Arctic Flora and Fauna	Not Released
Aquatic Coarse-Filter CEs	National Hydrography Dataset (NHD): Waterbodies	USGS	Obtained
Aquatic Coarse-Filter CEs	National Hydrography Dataset (NHD): Flowlines	USGS	Obtained
Terrestrial Fine-Filter CEs	Alaska GAP Analysis terrestrial vertebrate ocurrence database - sheep	Alaska Natural Heritage Program	Obtained
Terrestrial Fine-Filter CEs	Alaska GAP Modeled Habitat Distribution of Dall Sheep	Alaska Gap Analysis Project	Obtained
Terrestrial Fine-Filter CEs	Alaska GAP Analysis terrestrial vertebrate ocurrence database - beaver	Alaska Natural Heritage Program	Obtained
Terrestrial Fine-Filter CEs	Alaska GAP Modeled Habitat Distribution of Beaver	Alaska Gap Analysis Project	Obtained
Terrestrial Fine-Filter CEs	Alaska GAP Analysis terrestrial vertebrate ocurrence database - snowshoe hare	Alaska Natural Heritage Program	Obtained

CA / CE / MQ	Dataset Name	Data Source	Status
Terrestrial Fine-Filter CEs	Alaska GAP Modeled Habitat Distribution of Snowshoe Hare	Alaska Gap Analysis Project	Obtained
Terrestrial Fine-Filter CEs	Alaska GAP Analysis terrestrial vertebrate occurrence database - golden eagle	Alaska Natural Heritage Program	Obtained
Terrestrial Fine-Filter CEs	Alaska GAP Modeled Habitat Distribution of Golden Eagle	Alaska Gap Analysis Project	Obtained
Terrestrial Fine-Filter CEs	Alaska GAP Analysis terrestrial vertebrate occurrence database - gray-cheeked thrush	Alaska Natural Heritage Program	Obtained
Terrestrial Fine-Filter CEs	Alaska GAP Modeled Habitat Distribution of Gray-cheeked Thrush	Alaska Gap Analysis Project	Obtained
Terrestrial Fine-Filter CEs	Alaska GAP Analysis terrestrial vertebrate occurrence database - trumpeter swan	Alaska Natural Heritage Program	Obtained
Terrestrial Fine-Filter CEs	Alaska GAP Modeled Habitat Distribution of Trumpeter Swan	Alaska Gap Analysis Project	Obtained
Terrestrial Fine-Filter CEs	Habitat Management Guide - Caribou Ranges	Alaska Department of Fish and Game	Obtained
Terrestrial Fine-Filter CEs	Seasonal range polygons of all caribou herds in Alaska	Alaska Department of Fish and Game	Obtained
Terrestrial Fine-Filter CEs	Dall’s sheep occurrence points – Gate of the Arctic NPP, Noatak NP, Kobuk Valley NP.	National Park Service	Obtained
Terrestrial Fine-Filter CEs	Dall’s sheep occurrence points – Tanana Hills-White Mountains	US Fish and Wildlife Service	Obtained
Terrestrial Fine-Filter CEs	Space use and habitat selection of Hodzana Hills and Ray Mountain caribou herds (report)	Horne et al 2014	Obtained
Terrestrial Fine-Filter CEs	Caribou occurrence points, Kanuti NWR (report)	Craig and Benson 2012	Obtained
Terrestrial Fine-Filter CEs	Western Arctic caribou herd - Winter kernal range of the	National Park Service	Pending

CA / CE / MQ	Dataset Name	Data Source	Status
Terrestrial Fine-Filter CEs	Western Arctic caribou herd - Calving ground kernal analysis (report)	Alaska Department of Fish and Game	Pending
Terrestrial Fine-Filter CEs	Western Arctic caribou herd - fall migration routes (report)	Alaska Department of Fish and Game	Pending
Terrestrial Fine-Filter CEs	Porcupine caribou herd - Satellite/radio collar data	Alaska Department of Fish and Game	Pending
Terrestrial Fine-Filter CEs	40-Mile caribou herd - radio collar data	BLM/ADF&G	Pending
Terrestrial Fine-Filter CEs	White Mountains caribou herd - telemetry data	BLM	Pending
Terrestrial Fine-Filter CEs	Golden eagle nest sites in Tanana Hills	BLM	Pending
Aquatic Fine-Filter CEs	Anadromous Waters Catalog (AWC)	Alaska Department of Fish & Game	Obtained
Aquatic Fine-Filter CEs	Alaska Freshwater Fish Inventory (AFFI)	Alaska Department of Fish & Game	Requested
Aquatic Fine-Filter CEs	Seasonal movements of northern pike in Minto Flats	Alaska Department of Fish & Game	Requested
Aquatic Fine-Filter CEs	Summer growth of juvenile Chinook salmon in Interior Alaskan river	Alaska Department of Fish & Game; University of Alaska Fairbanks	Requested
Aquatic Fine-Filter CEs	Spawning movements of humpback whitefish in Interior Alaskan rivers	University of Alaska Fairbanks	Requested
MQ: AH1, G1, G2	Alaska Rare Ecosystem Database	Alaska Natural Heritage Program	Obtained
MQ: AH1, G1, G2	Alaska Rare Plant Database	Alaska Natural Heritage Program	Obtained